

Development of a Laboratory-Scale Test for Evaluating the Decomposition Products Generated Inside an Intact Fuselage During a Simulated Postcrash Fuel Fire



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Outline

- Purpose
- Background
- Laboratory Scale Test Rig for Evaluation of Buildup of:
 - Toxic Gases
 - Flammable Gases
- Insulation Systems Tested
- Gas Sampling Methodology
- Gases Measured
- Methods of Analysis
- Results
- Coclusions

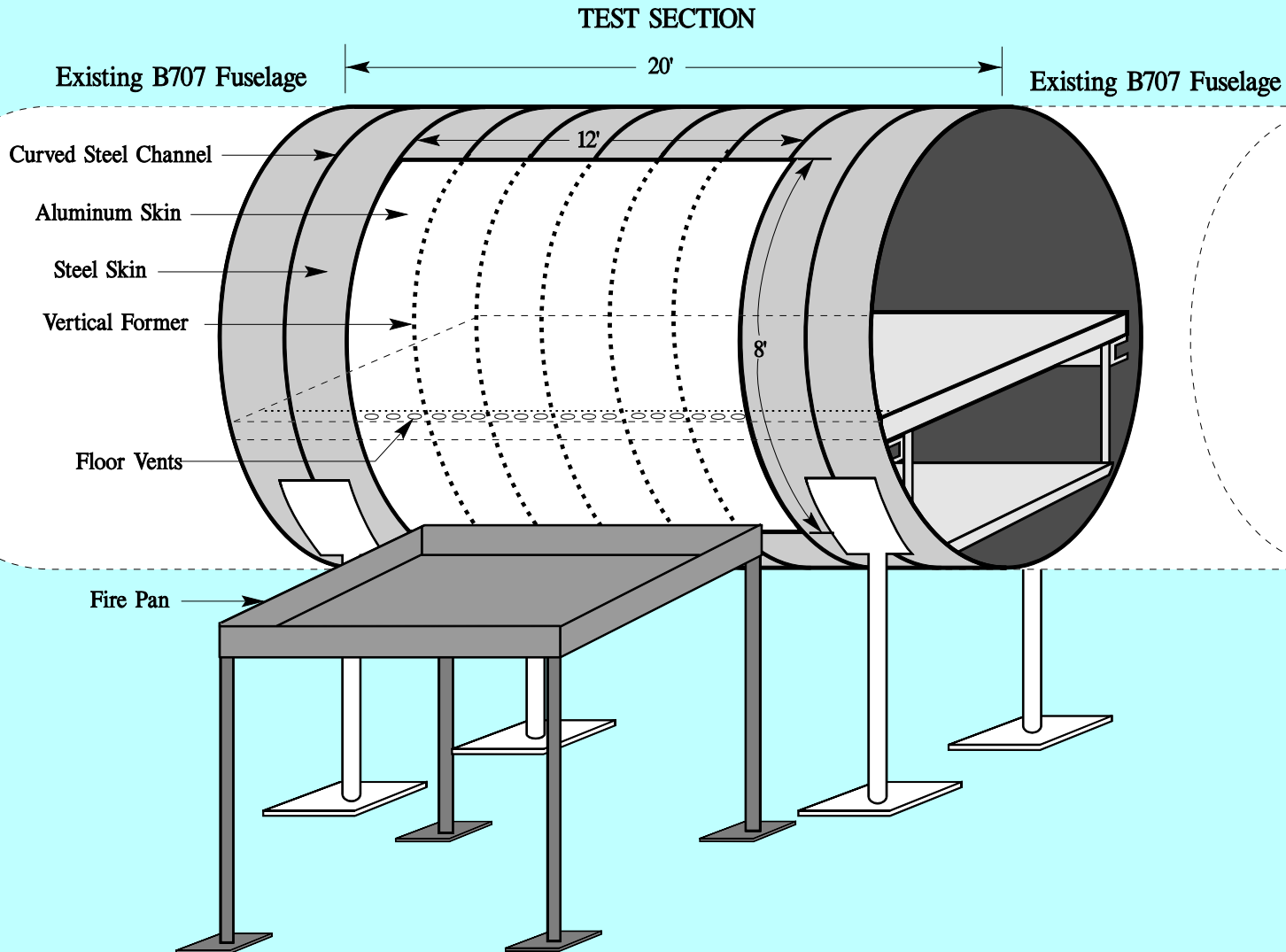


Purpose

- Develop a laboratory-scale test to evaluate the thermal decomposition products that accumulate inside an intact transport category fuselage during exposure to a simulated external fuel fire.
- Perform this test on:
 - Two thermal acoustical insulation configurations.
 - A prototype structural composite material (without thermal acoustic insulation).
- Measure buildup of gases within test enclosure.
 - Toxic gases
 - Flammable gases
- Compare test results for the 3 material systems.
- Subsequent tests will be conducted on a fire-hardened Full-Scale Burntrough Test Rig to provide a scaling factor for gas concentration data.

Background

Full-Scale Fuselage Burnthrough Test Rig





Background

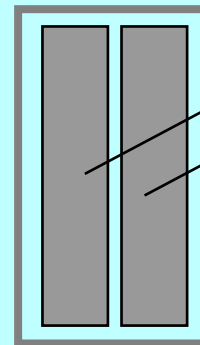
B-707 Burnthrough Test of Polyacrylonitrile (PAN) Insulation Assembly

**Aluminum
Skin**



+

**Insulation
Assembly**



lofted PAN

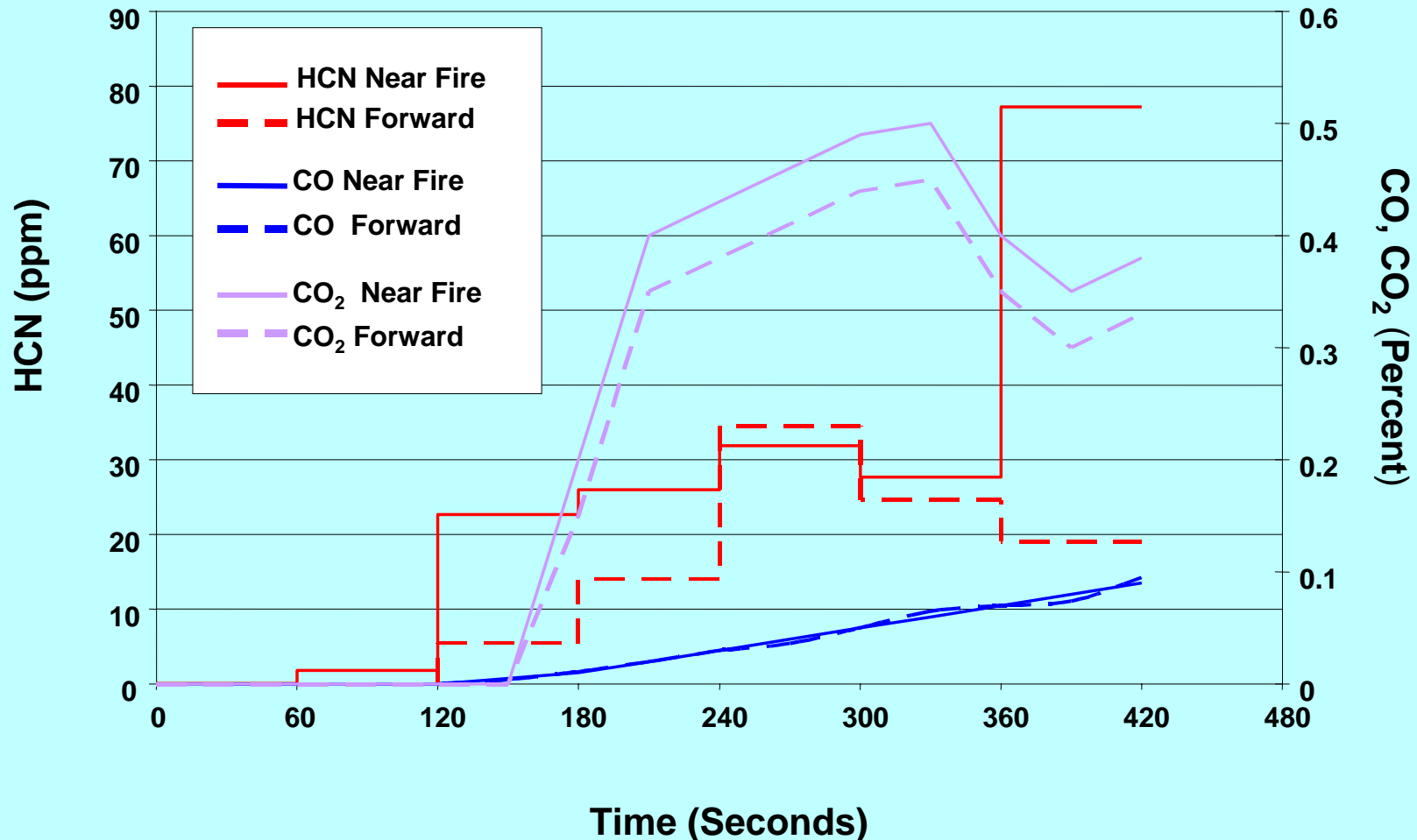
met PVF film

HCN, CO and CO₂ Measured During Full-Scale Test With Polyacrylonitrile Insulation

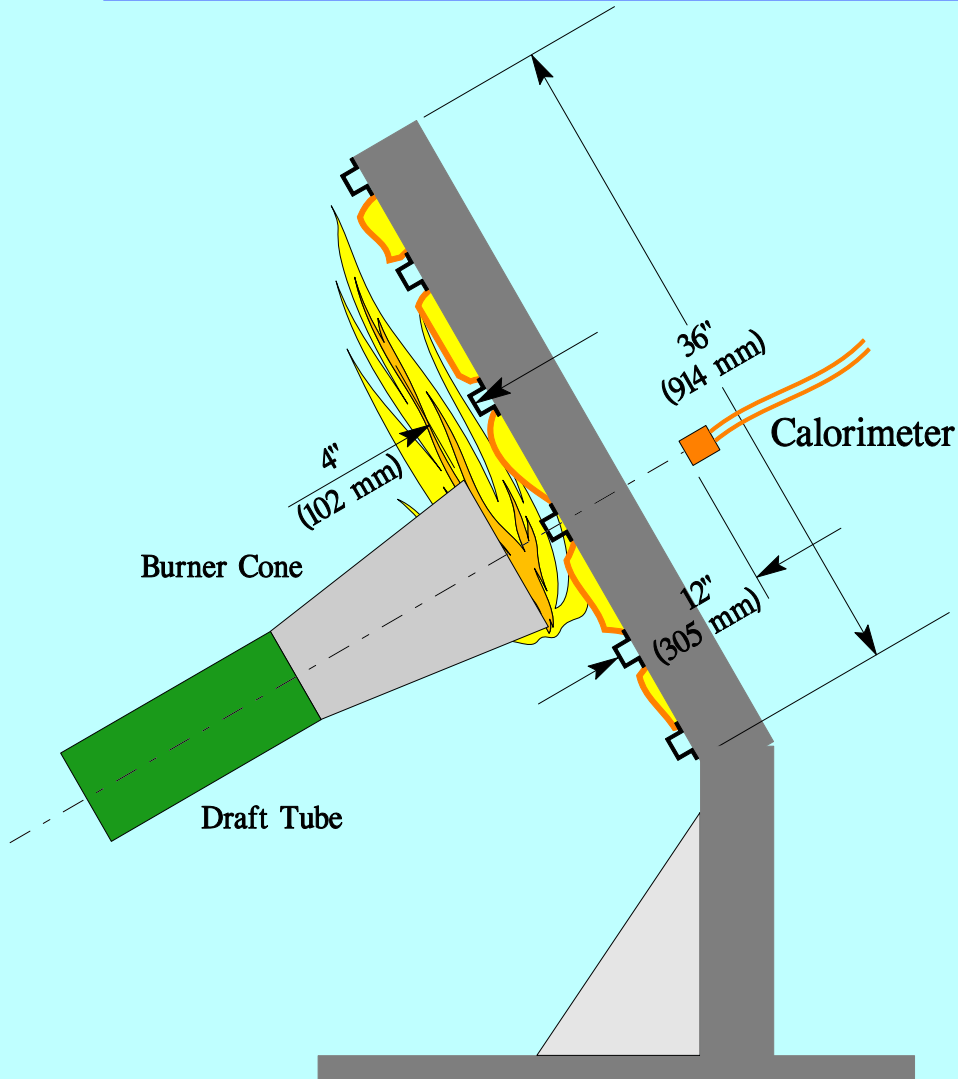


1.5 inch Curlon FB-300SA with AN-18R Tedlar film with polyester reinforcement

Fractional Effective Dose (Incapacitation) at 5 minutes = 0.1



Insulation Burnthrough Test Apparatus

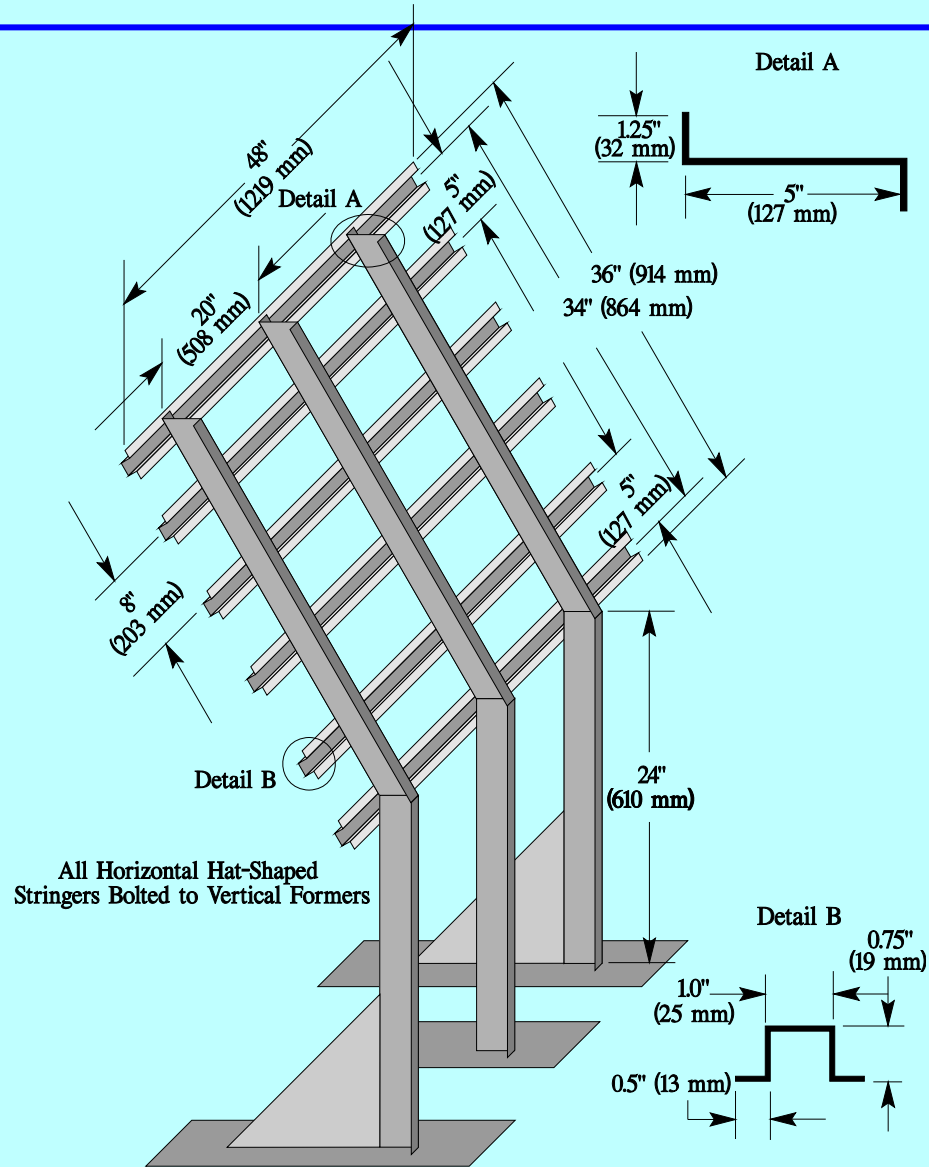


Flame Temperature = 1900° F

Heat Flux = 16.0 Btu/ft²sec

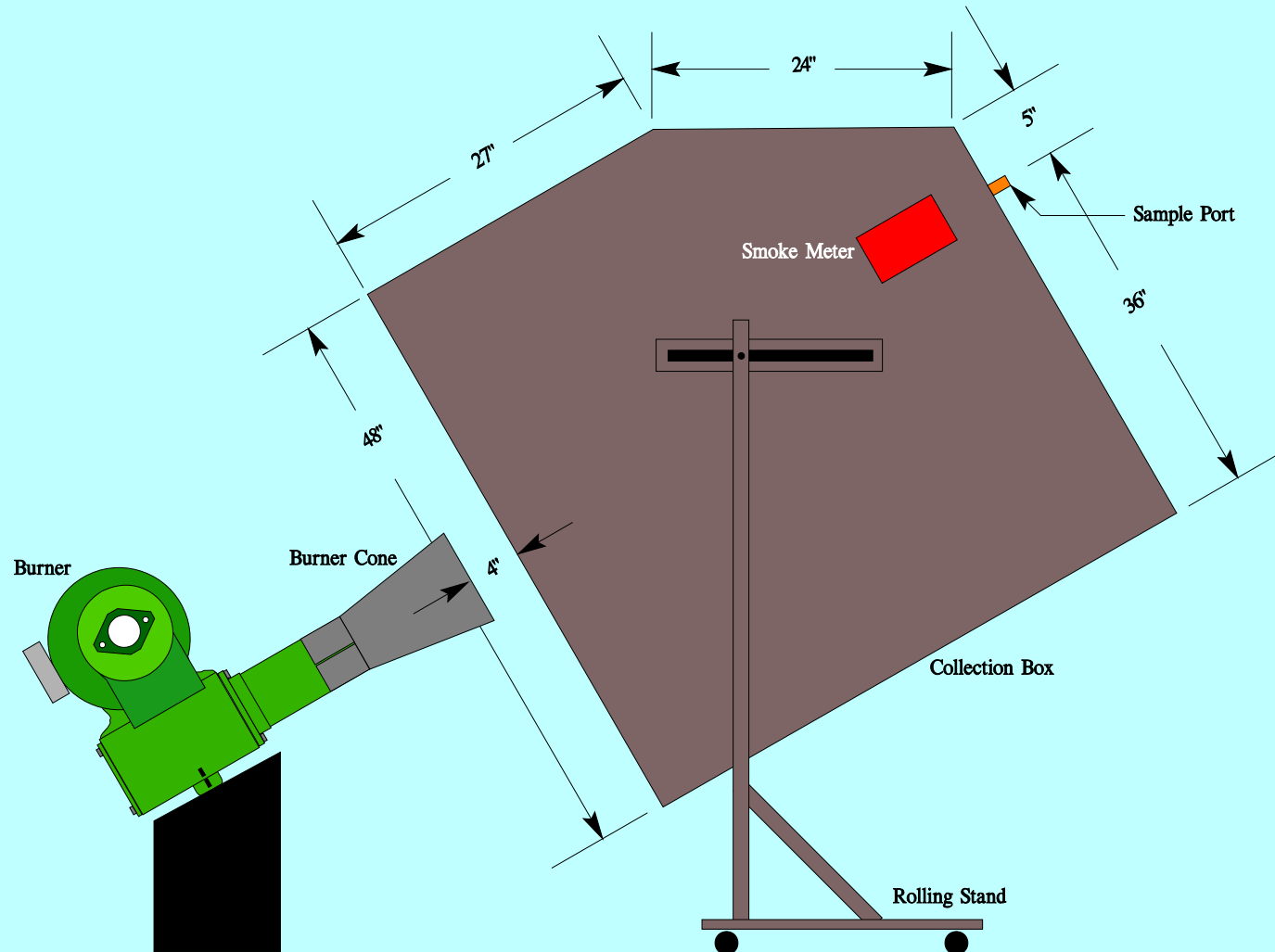
- *This configuration yielded results that correlated with previous full scale tests that used identical materials*
- *Title 14 Code of Federal Regulations (CFR) Part 25.856(b)*

Insulation Burnthrough Test Sample Holder



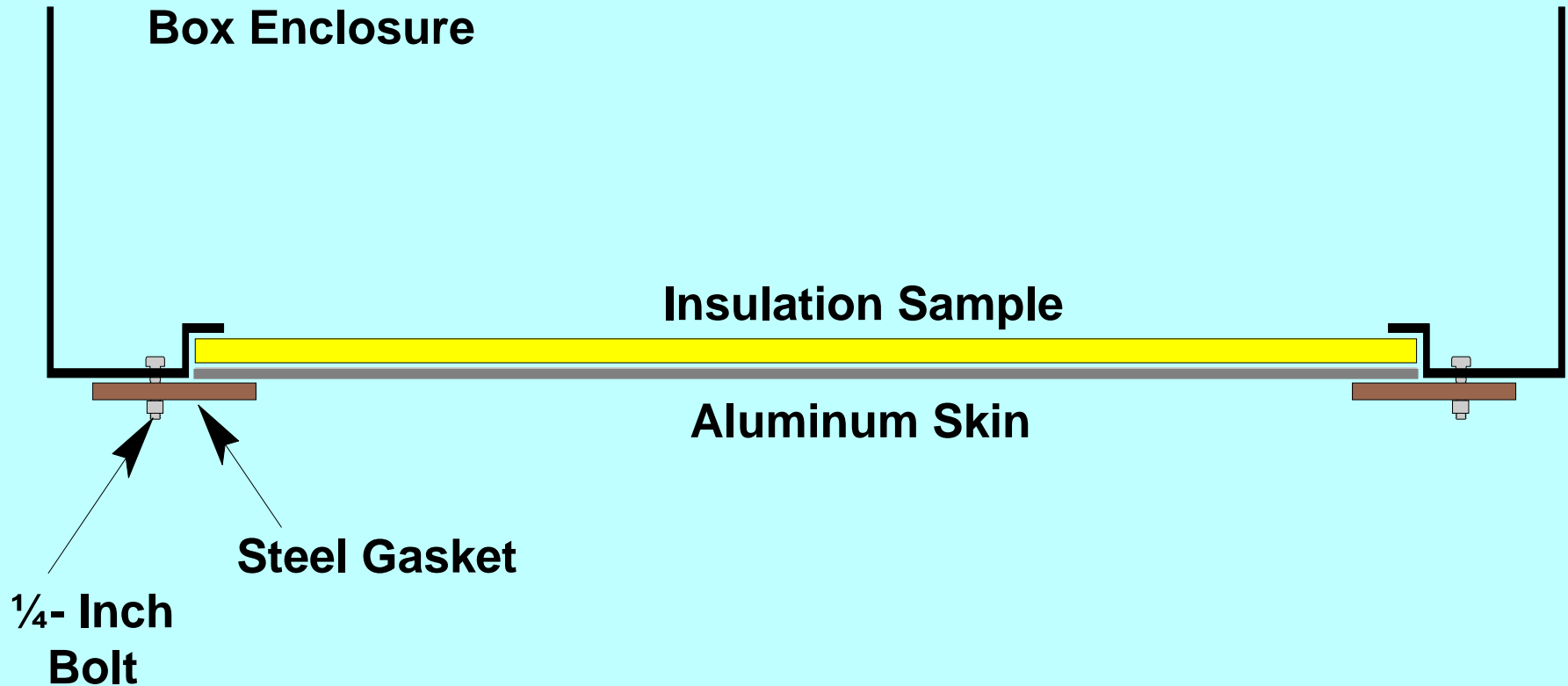
All Material 0.125" (3 mm) Thickness Except Center Vertical Former, 0.250" Thick (6 mm)

Test Apparatus for Evaluating the Toxicity of Insulation Materials





Box Enclosure Mounting System



Sample Size: 40- by 40 inch

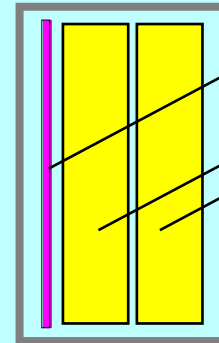
Material Systems Tested

**Ceramic Barrier/
FG/Met PVF Film
Test**

Alum Skin



+



Nextel ceramic barrier

lofted fiberglass

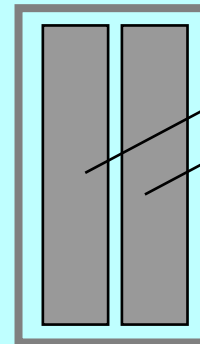
met PVF film

**PAN/Met PVF Film
Test**

Alum Skin



+



lofted PAN

met PVF film

**Advanced
Composite Material
Test**

ACM Skin





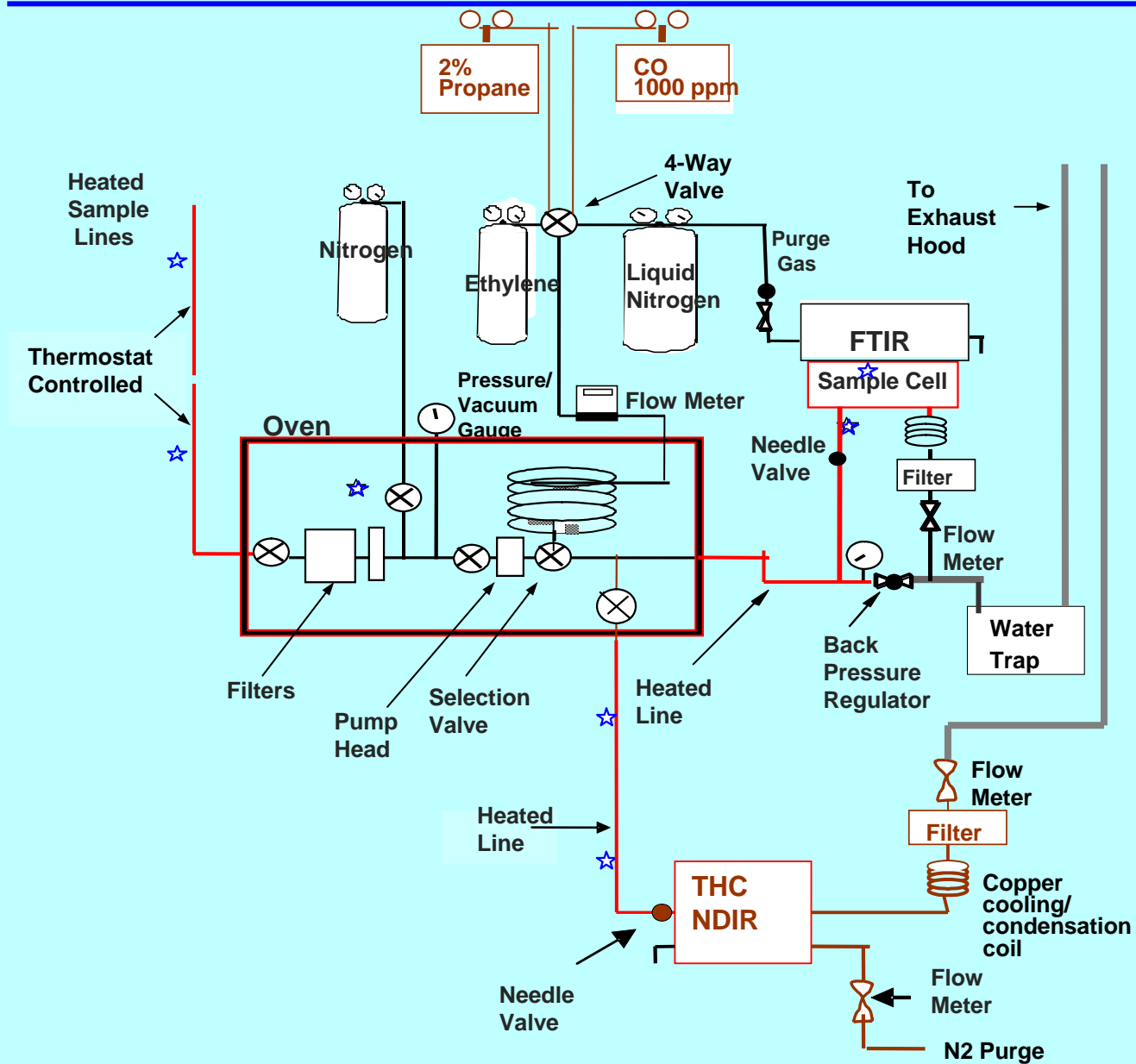
Gases Measured by FTIR

Toxic Gases	
C ₆ H ₅ NH ₂	aniline
C ₆ H ₅ OH	phenol
C ₆ H ₆	benzene
CH ₂ CHCHO	acrolein
CH ₄	methane
CO	carbon monoxide
CO ₂	carbon dioxide
COCl ₂	phosgene
COF ₂	carbonyl fluoride
COS	carbonyl sulfide
HBr	hydrogen bromide
HCl	hydrogen chloride
HCN	Hydrogen cyanide
HF	Hydrofluoric acid
NH ₃	ammonia
NO	nitrogen oxide
NO ₂	nitrogen dioxide
SO ₂	sulfur dioxide

Flammable Gases	
C ₂ H ₂	acetylene
C ₂ H ₄	ethylene
C ₂ H ₆	ethane
C ₃ H ₈	propane
C ₆ H ₅ NH ₂	aniline
C ₆ H ₅ OH	phenol
C ₆ H ₆	benzene
CH ₂ CHCHO	acrolein
CH ₄	methane
Other Gases	
CO ₂	carbon dioxide
H ₂ O	water
N ₂ O	nitrous oxide



FTIR and THC Sampling System

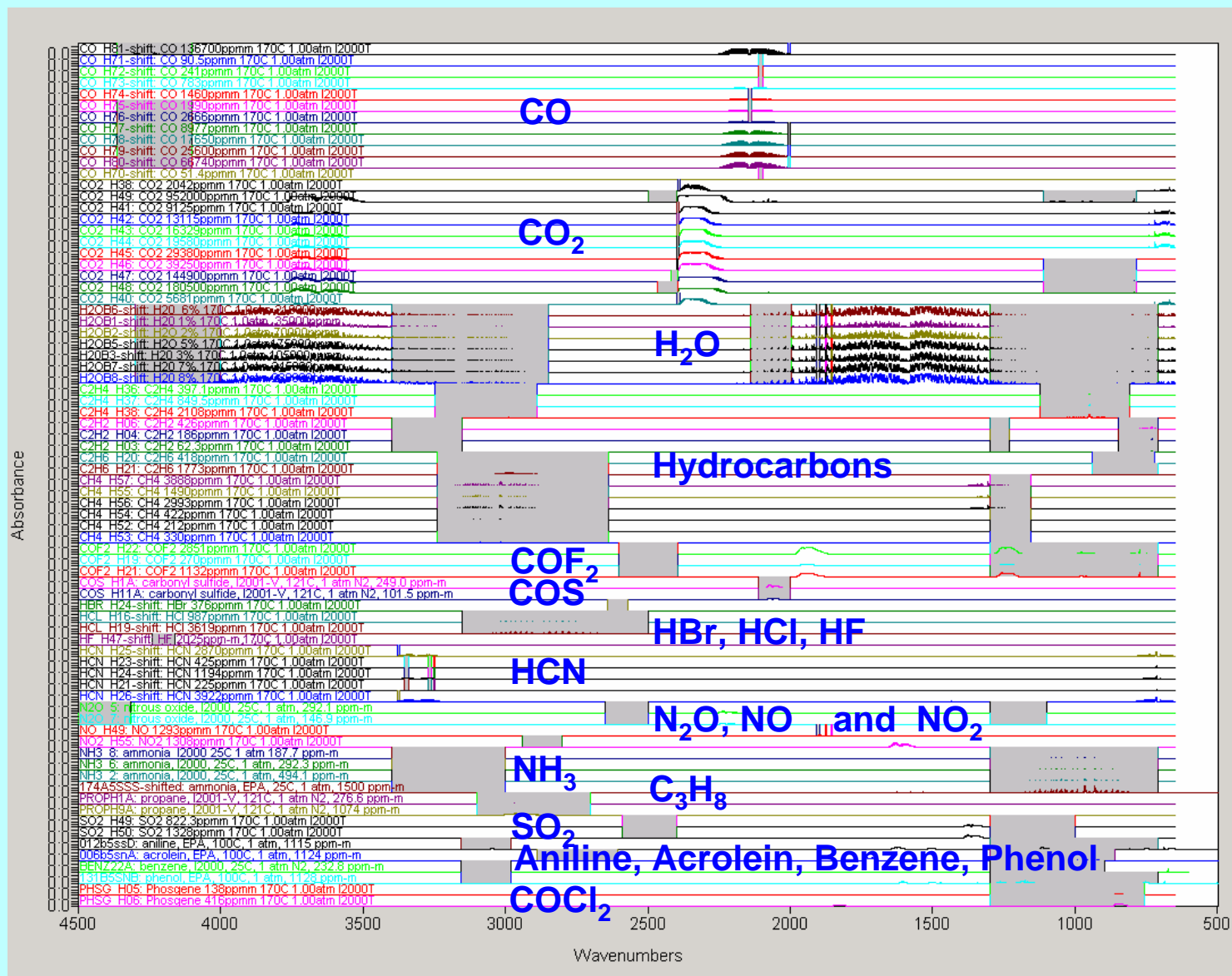


FTIR Spectrometer

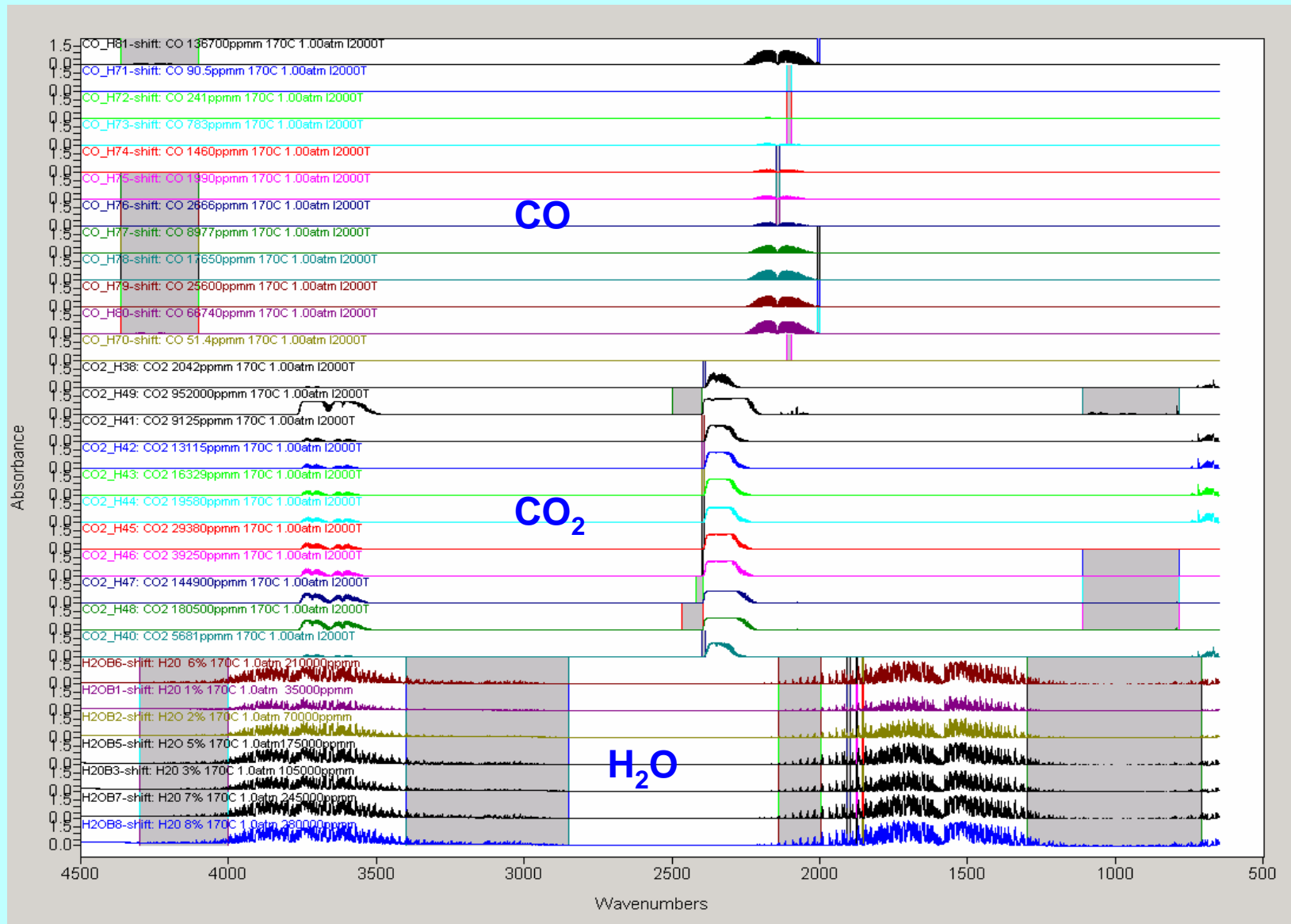


Optical path of sample cell	4-meters
Cell volume	160ml
Cell Temperature	170°C
Optics	ZnSe with germanium coating
Detector	Liquid Nitrogen cooled Mercury Cadmium Telluride
All interface Optics	Gold coated
Mode	Extractive
Resolution	0.5 cm-1
Sample rate	16 scans averaged every 9 seconds
FTIR Software	Midac Autoquant Pro

Calibration Spectra and Selected Regions for FTIR Analysis

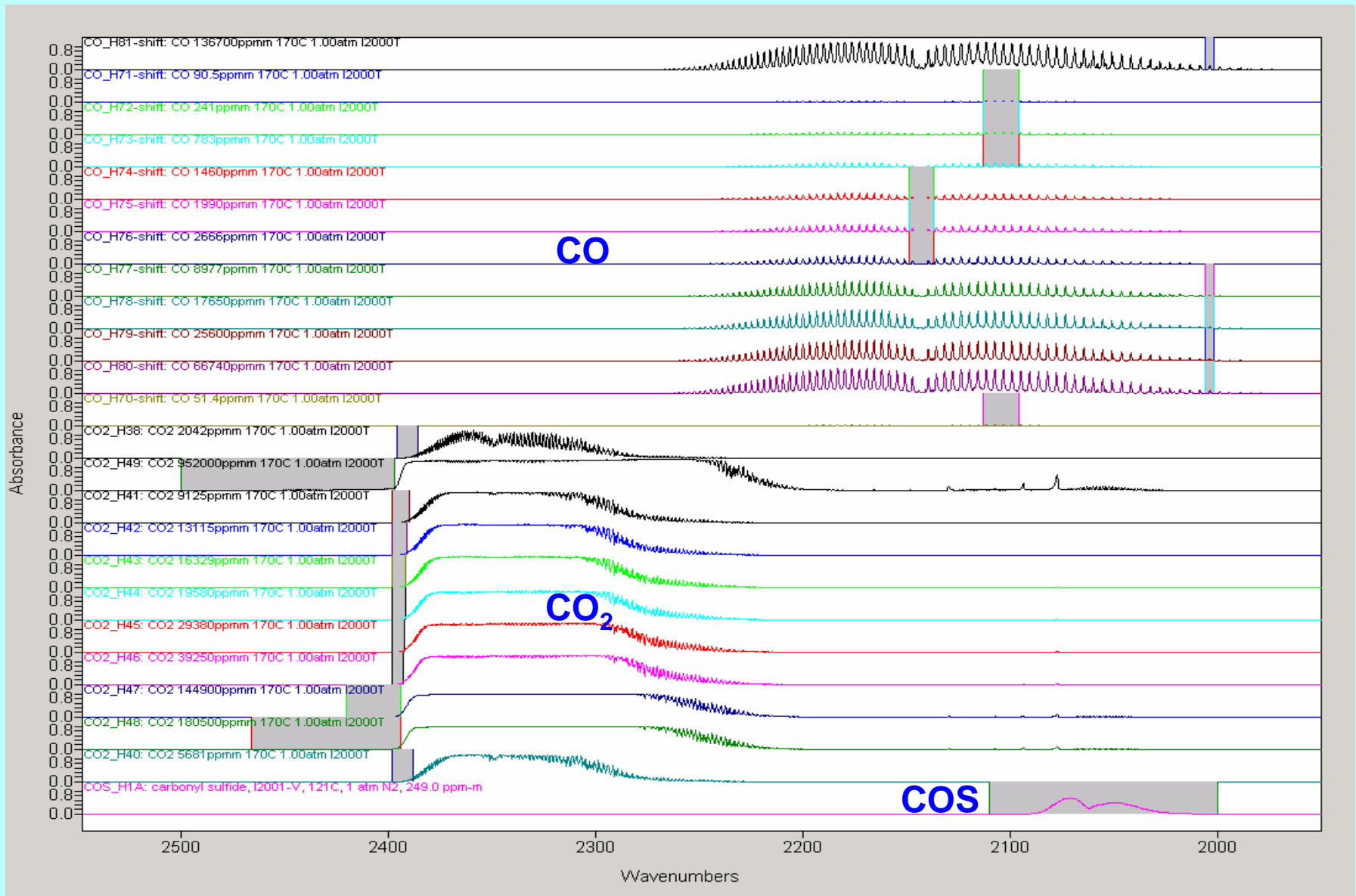


CO and CO₂ and Water Spectra and Regions

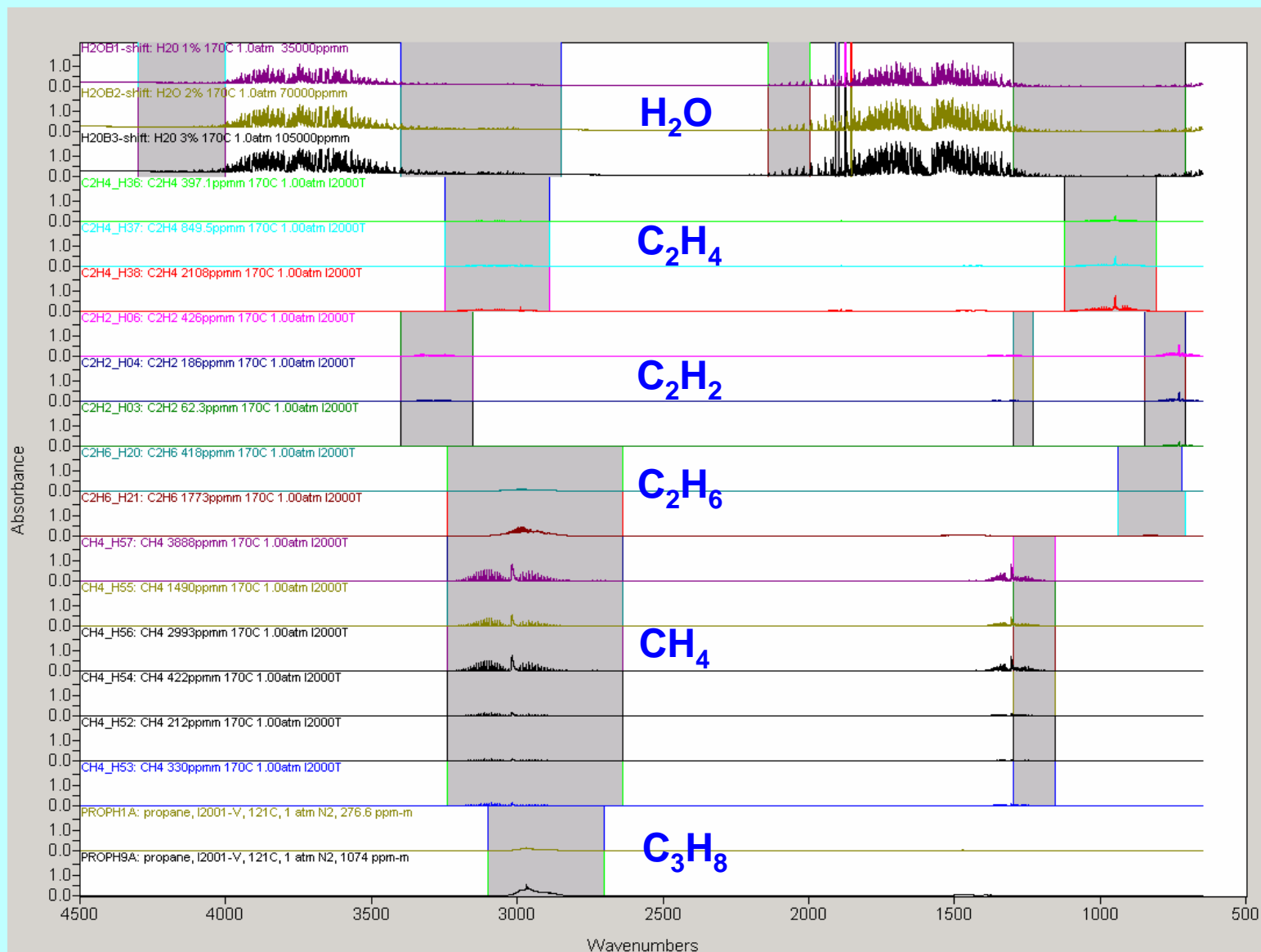


CO, CO₂ and COS Spectra and Regions

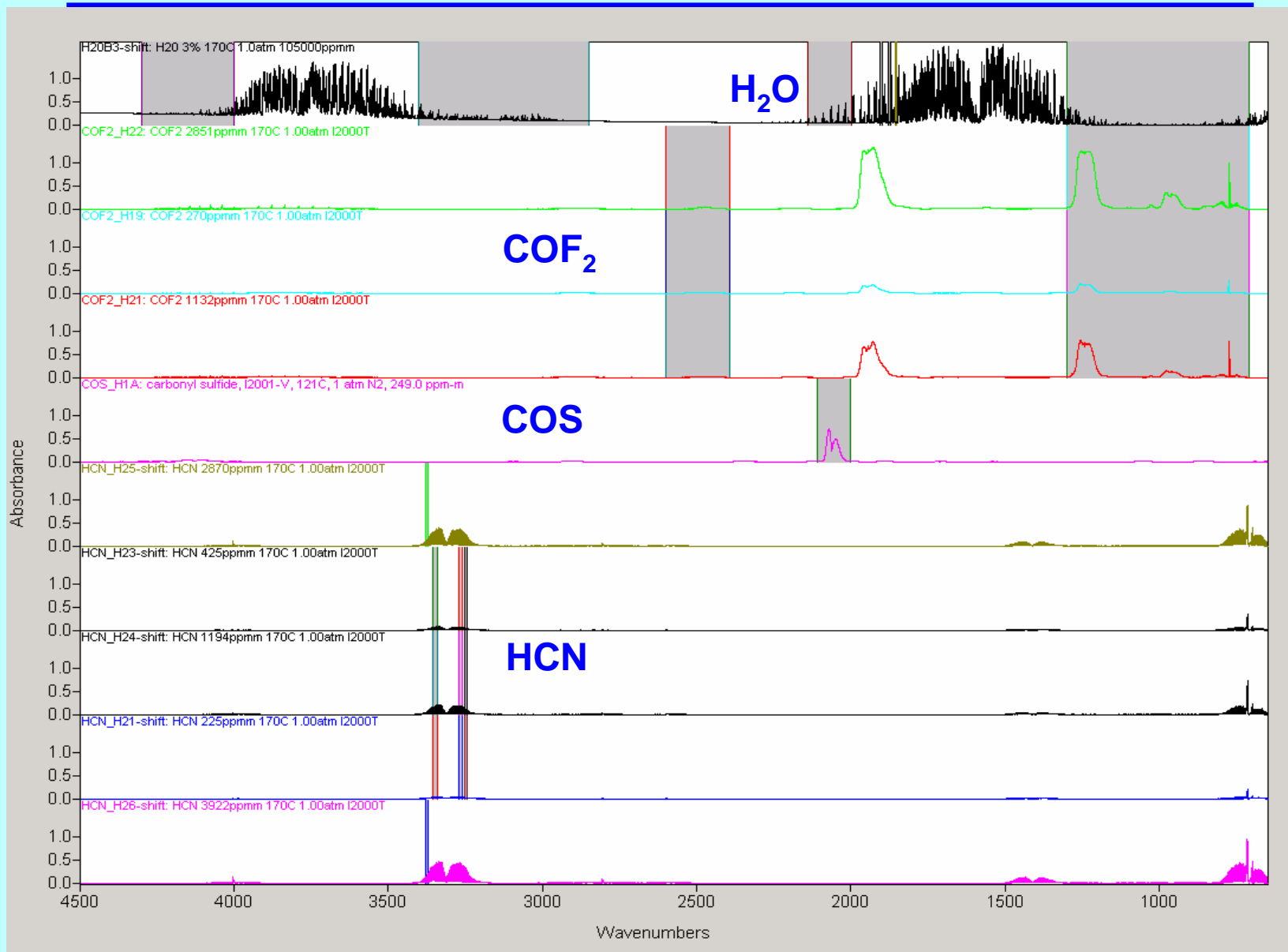
Expanded View



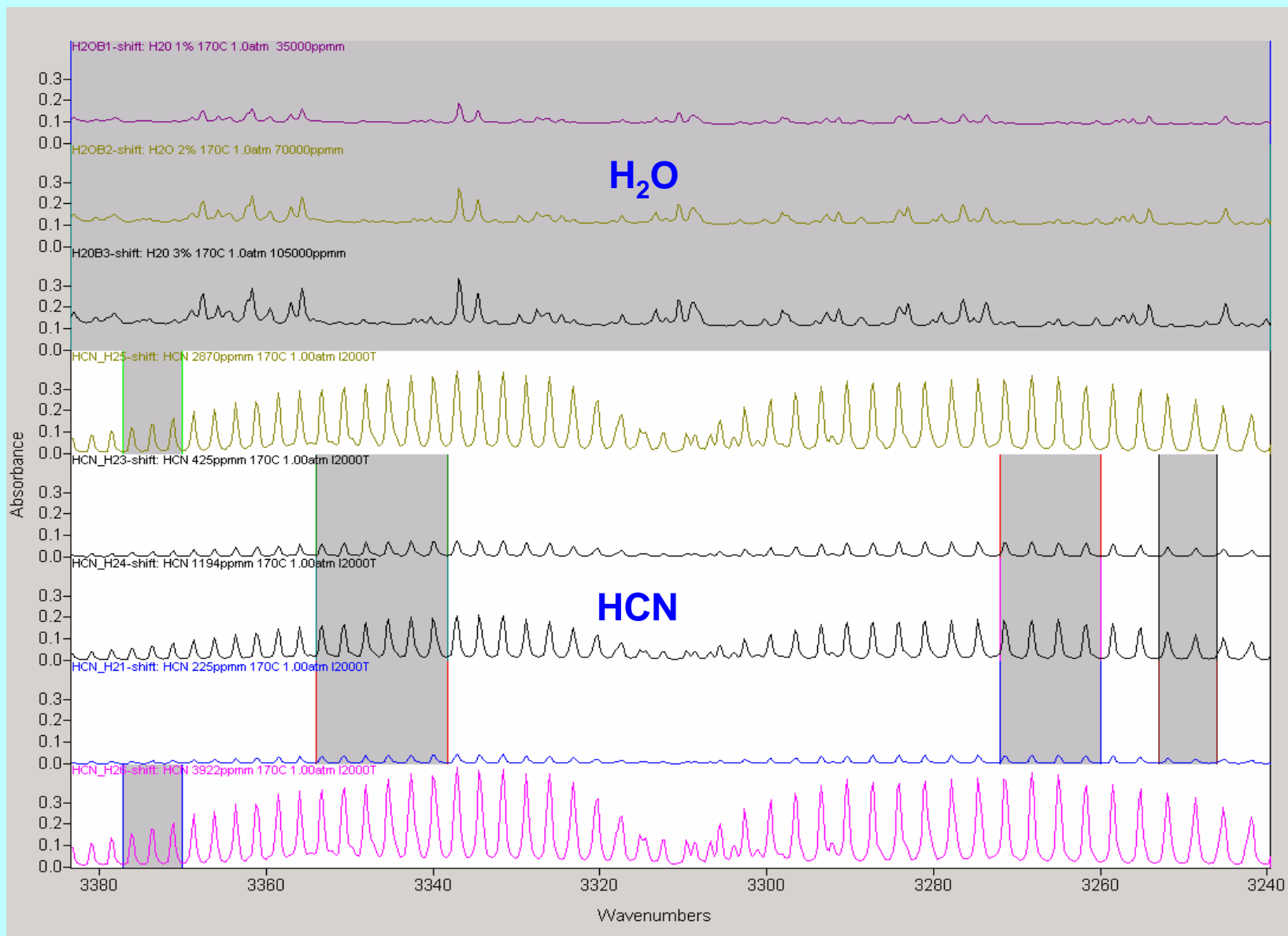
H_2O , C_2H_4 , C_2H_2 , C_2H_6 , CH_4 , and C_3H_8 Spectra and Regions



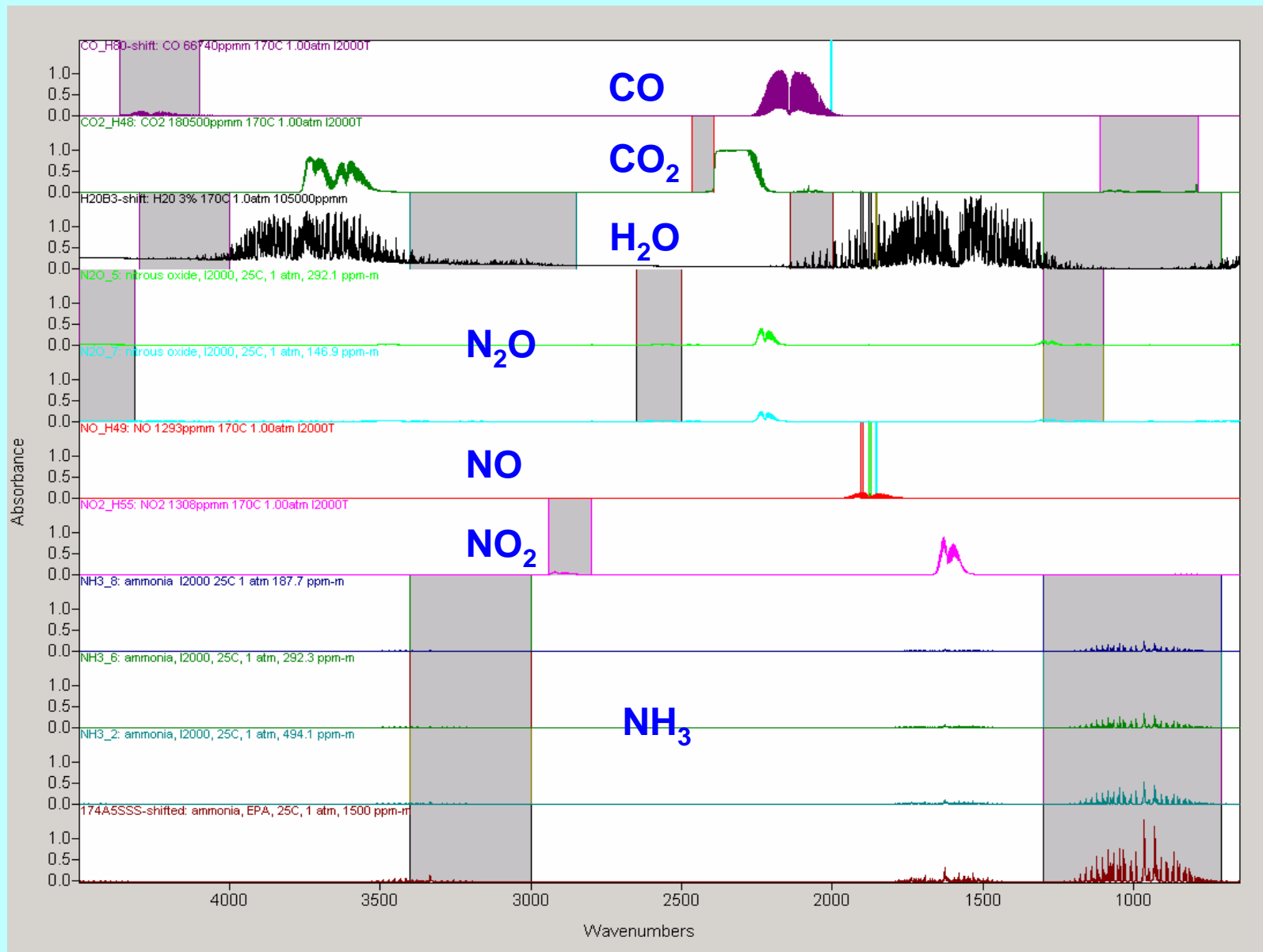
H₂O, COF₂, COS, and HCN Spectra and Regions



H₂O and HCN: Expanded View

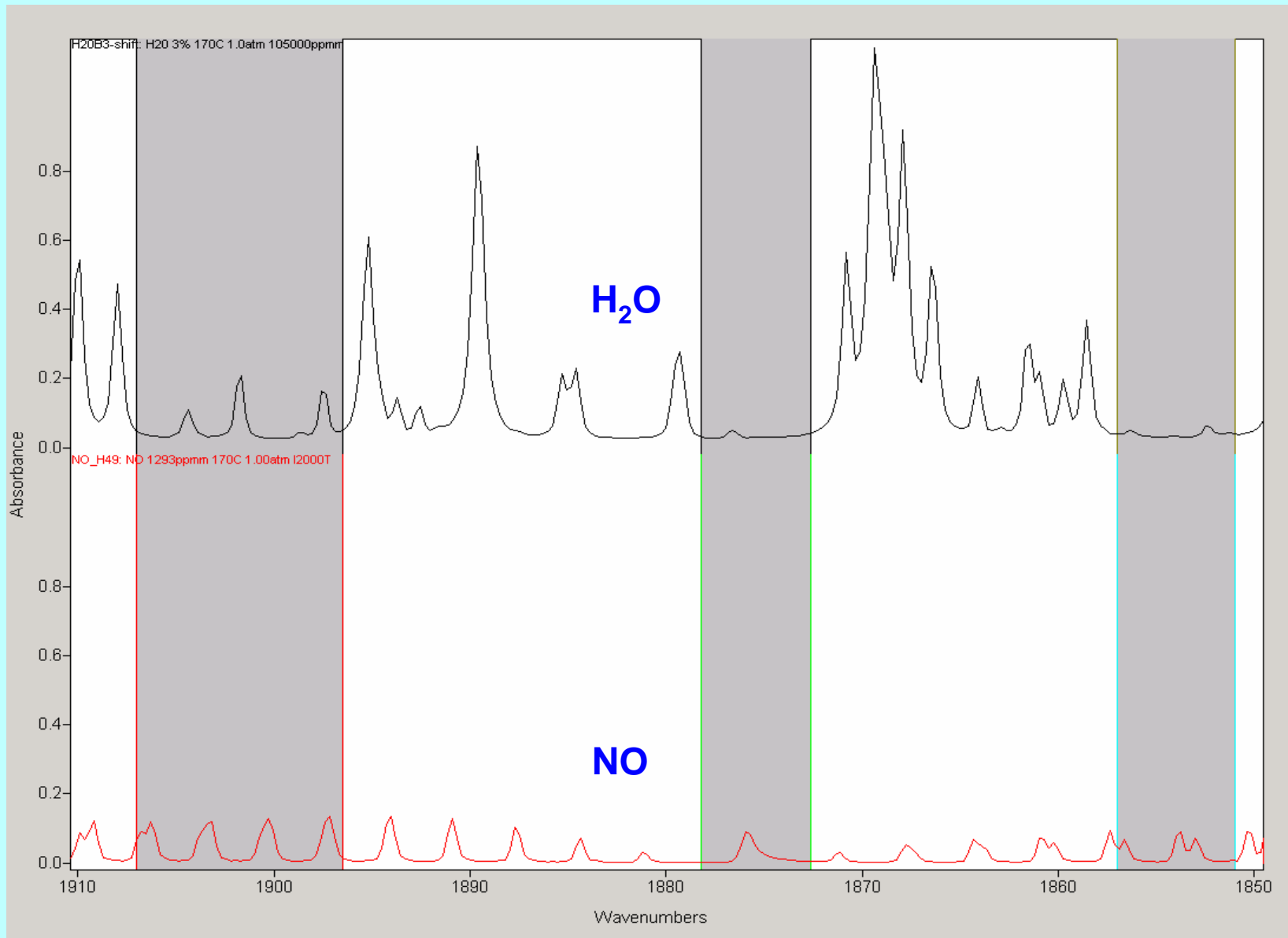


N_2O , NO , NO_2 and NH_3 Spectra and Regions

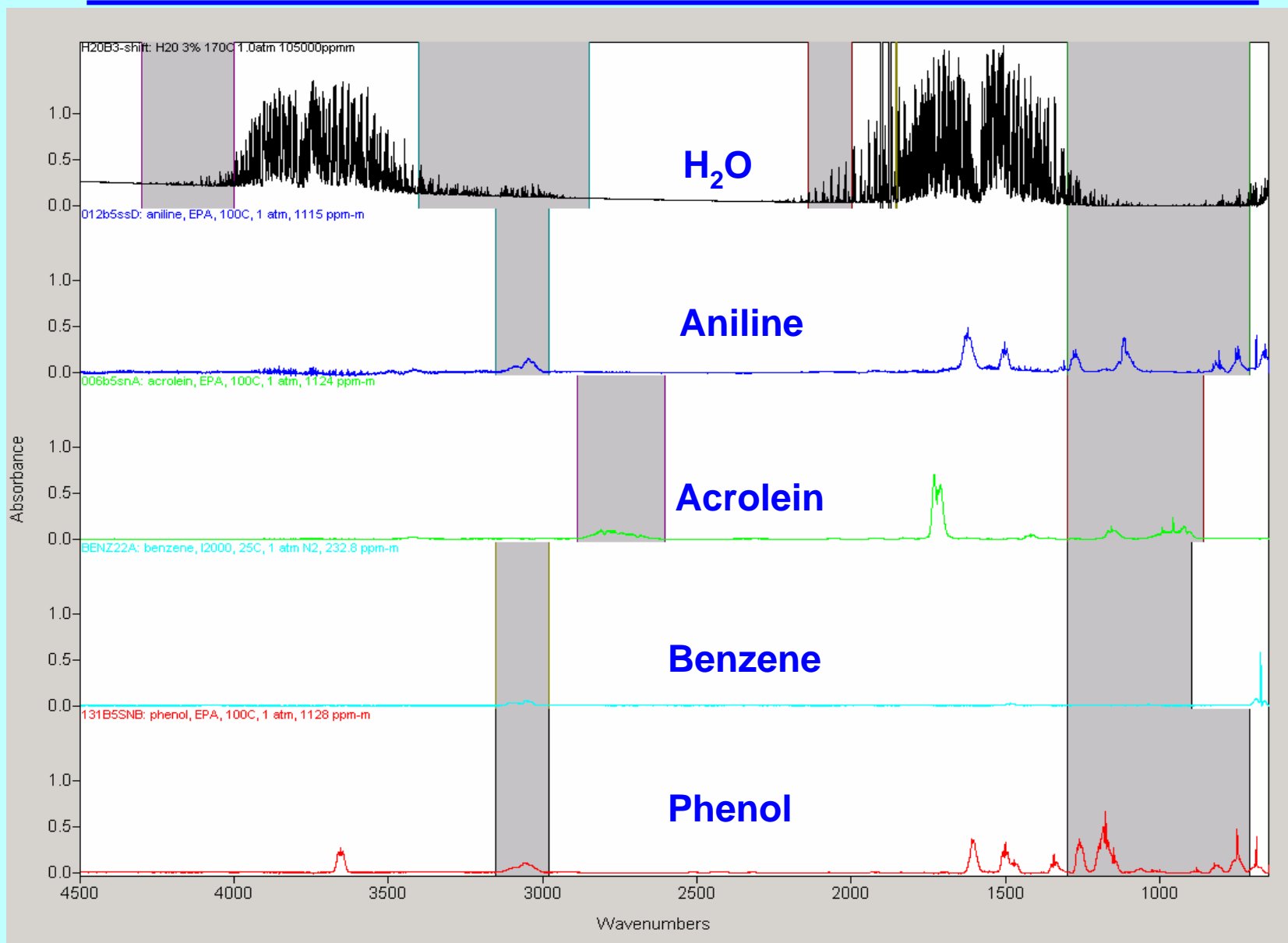




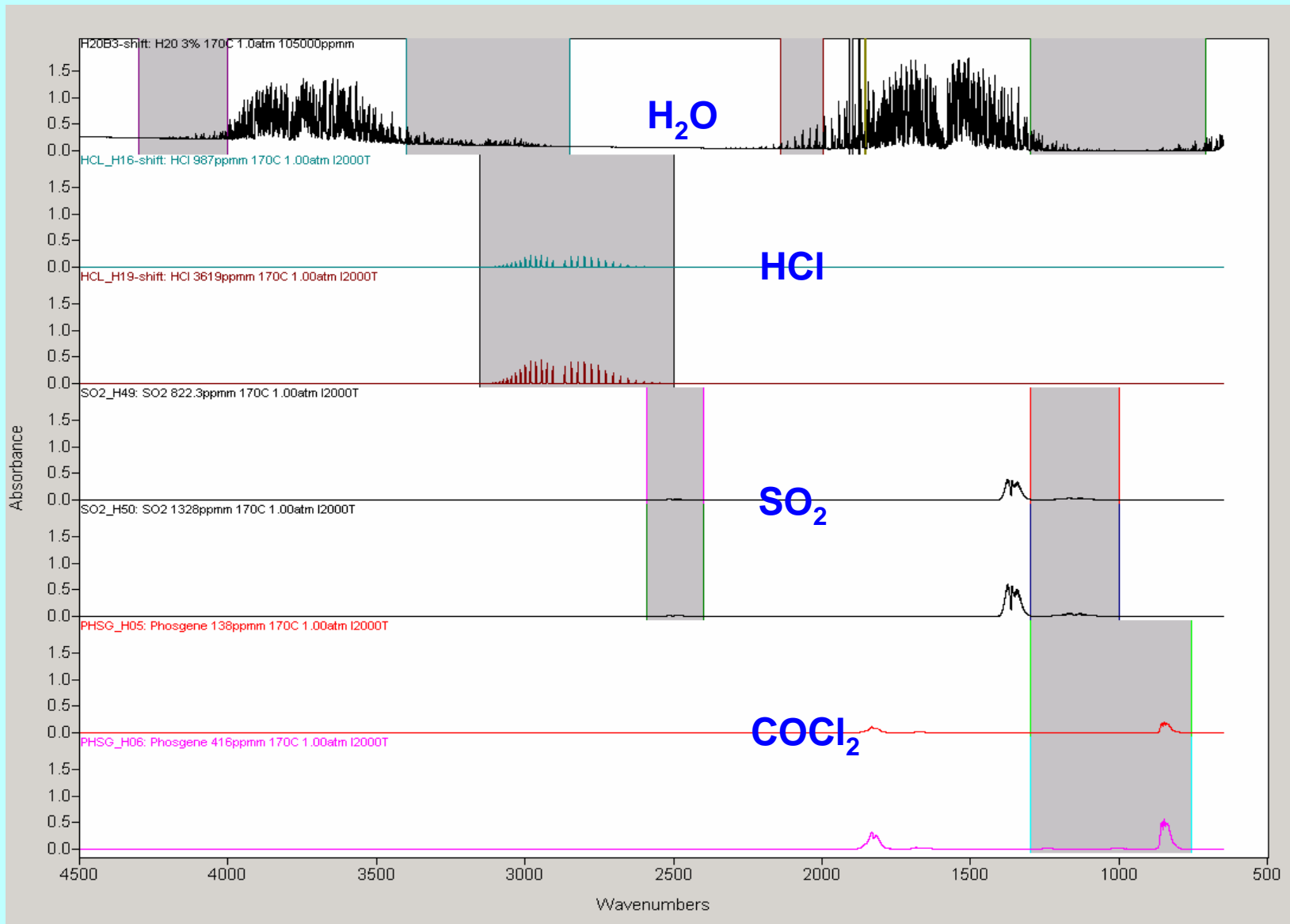
H₂O and NO: Expanded View



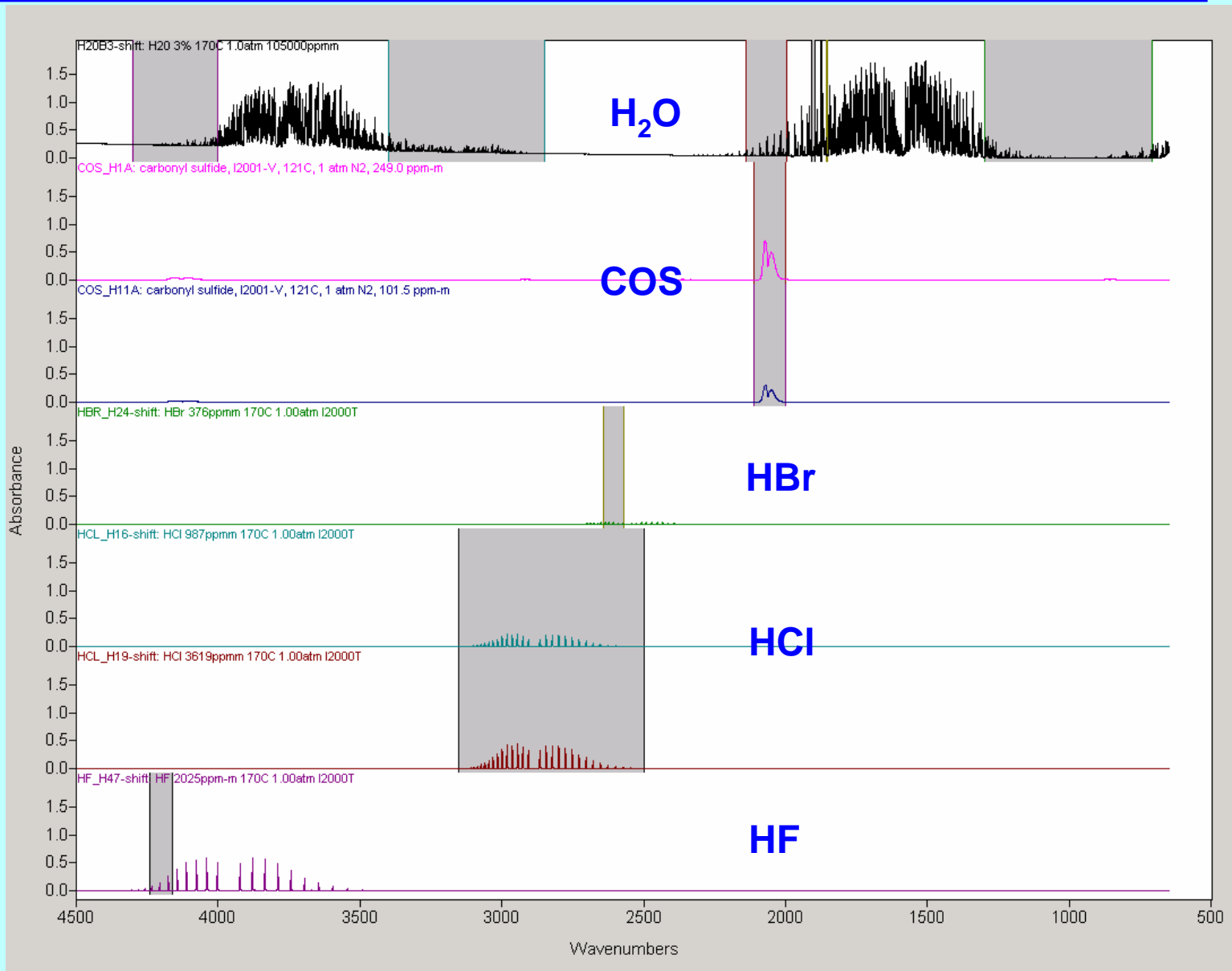
H₂O, Aniline, Acrolein, Benzene, and Phenol Spectra and Regions



H₂O, HCl, SO₂ and COCl₂ Spectra and Regions



H₂O, COS, HBr, HCl and HF Spectra and Regions



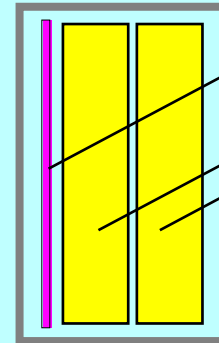
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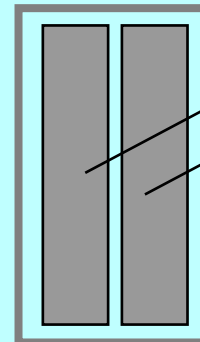
met PVF film

**PAN/Met PVF Film
Test**

Alum Skin



+



lofted PAN

met PVF film

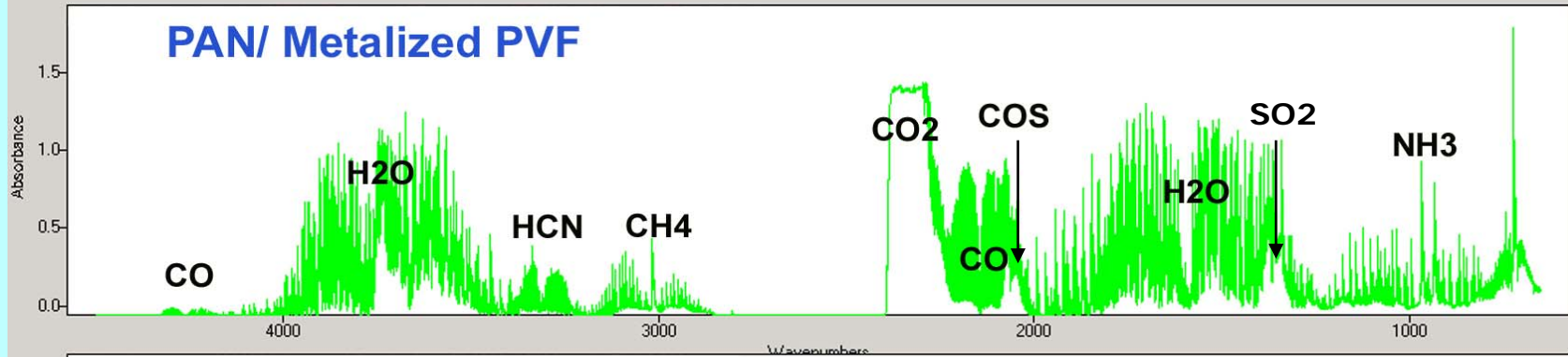
**Advanced
Composite Material
Test**

ACM Skin

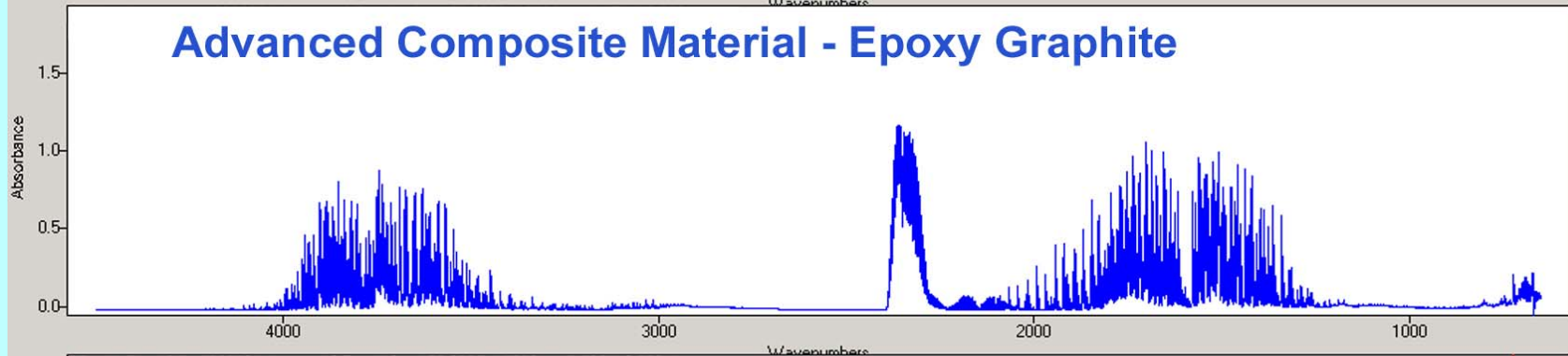


Spectra at 5 Minutes

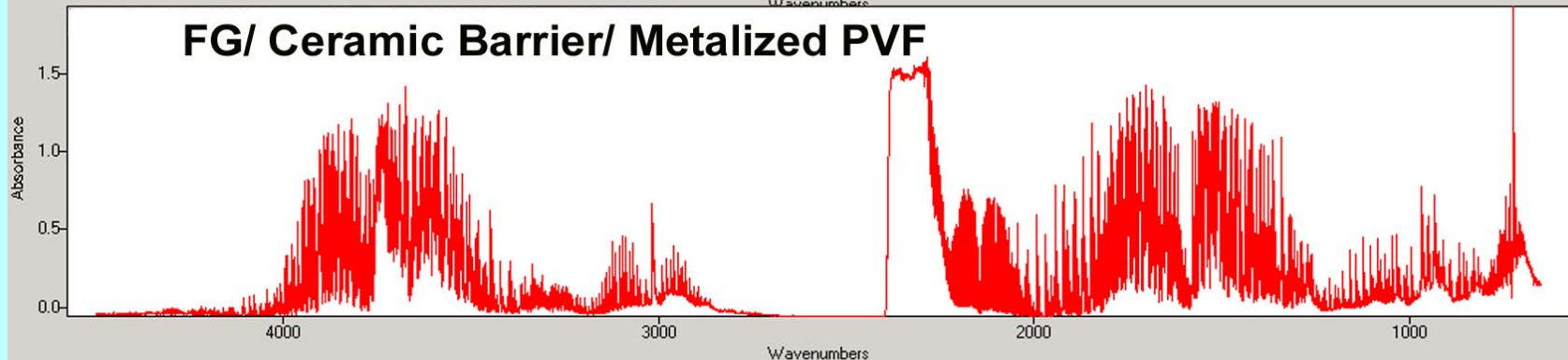
PAN/ Metalized PVF



Advanced Composite Material - Epoxy Graphite



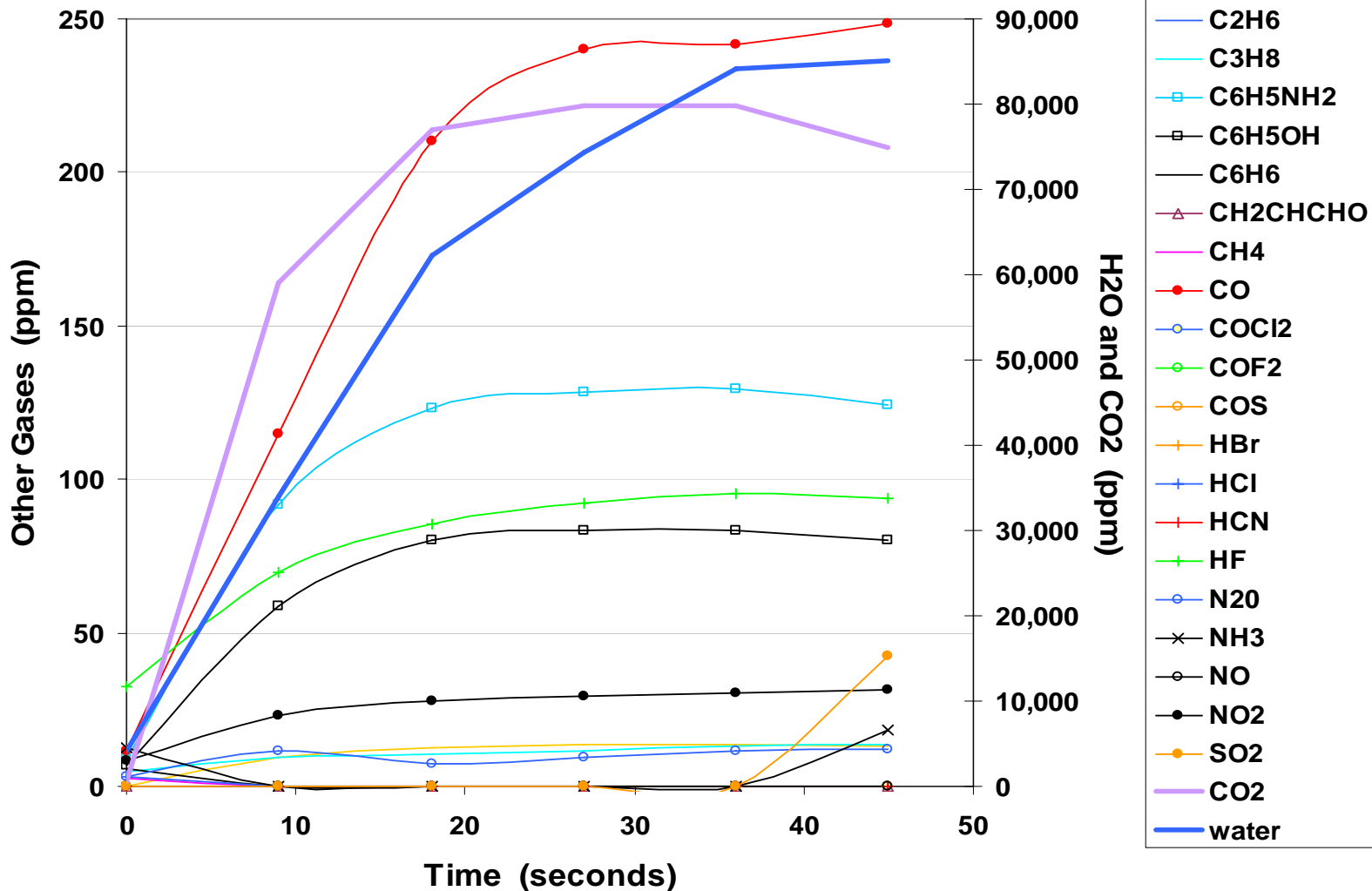
FG/ Ceramic Barrier/ Metalized PVF



Concentration Histories for Open-Box Test Obtained by FTIR Analysis



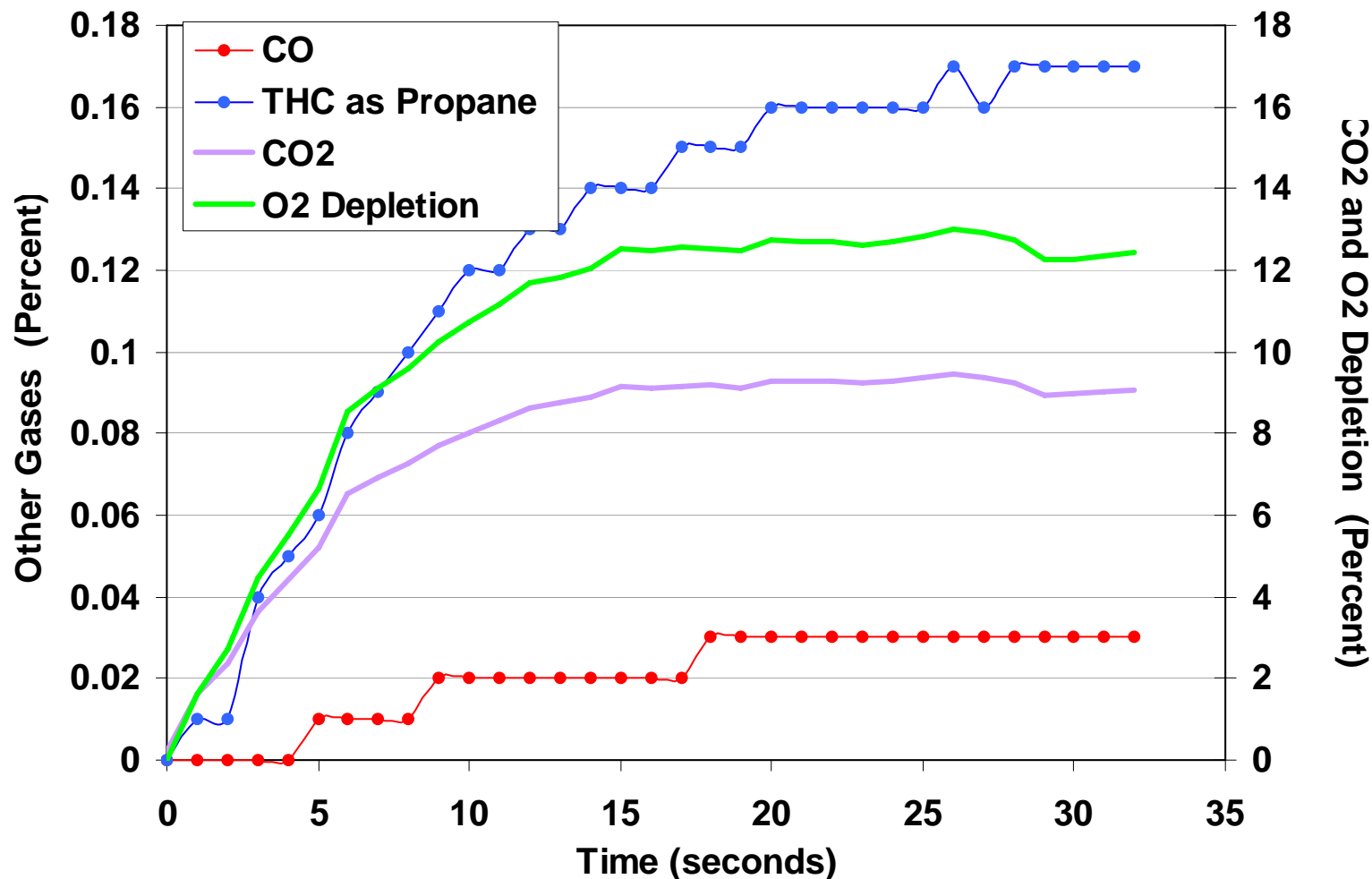
051213 ACM-- Box Test 6-- Open Box



Concentration Histories for Open-Box Test Obtained by Gas Analyzers



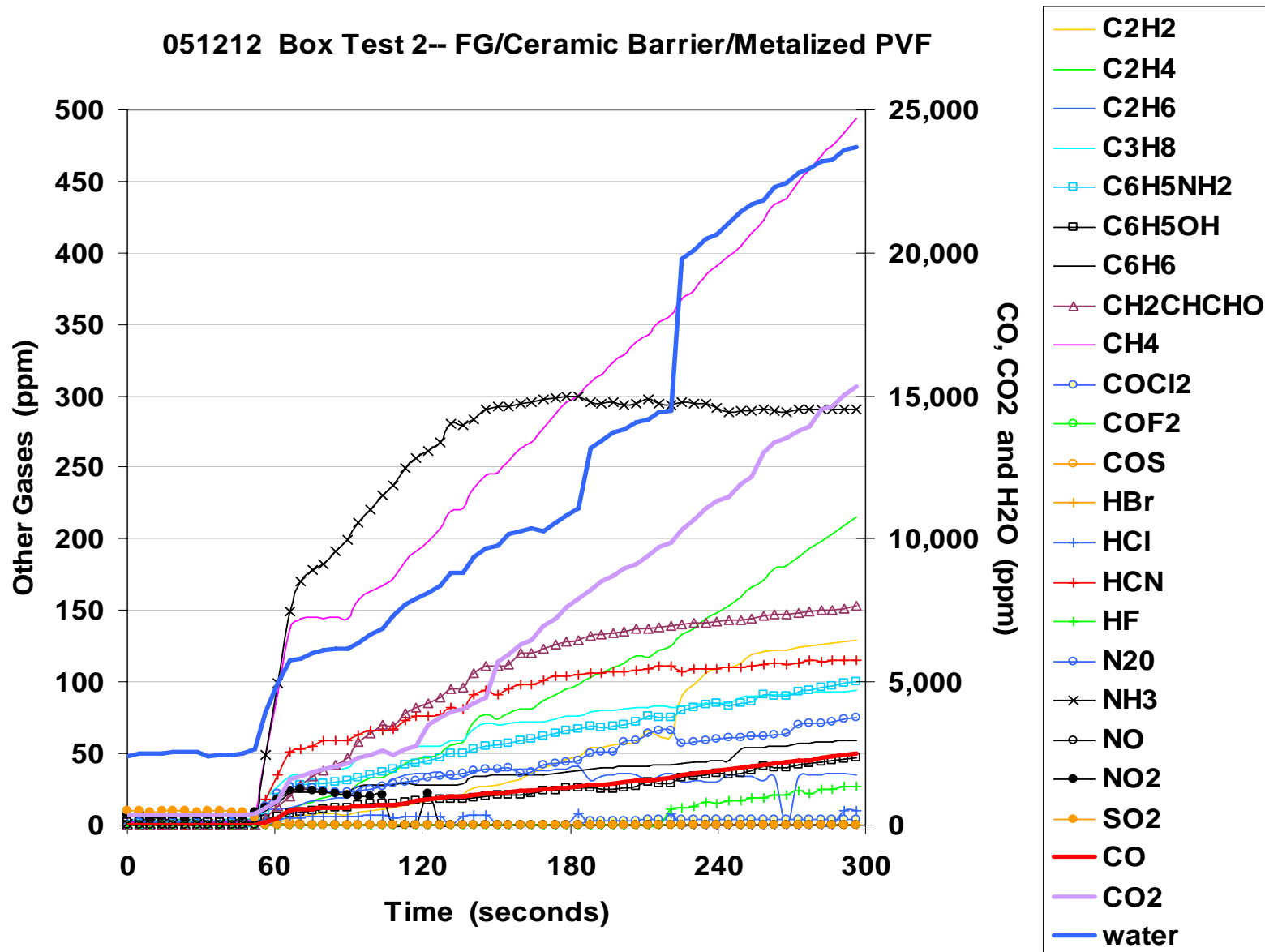
051213 Box Test 6- Open Box



Concentration Histories of FG/Ceramic Barrier Insulation System Box Test Obtained by FTIR Analysis



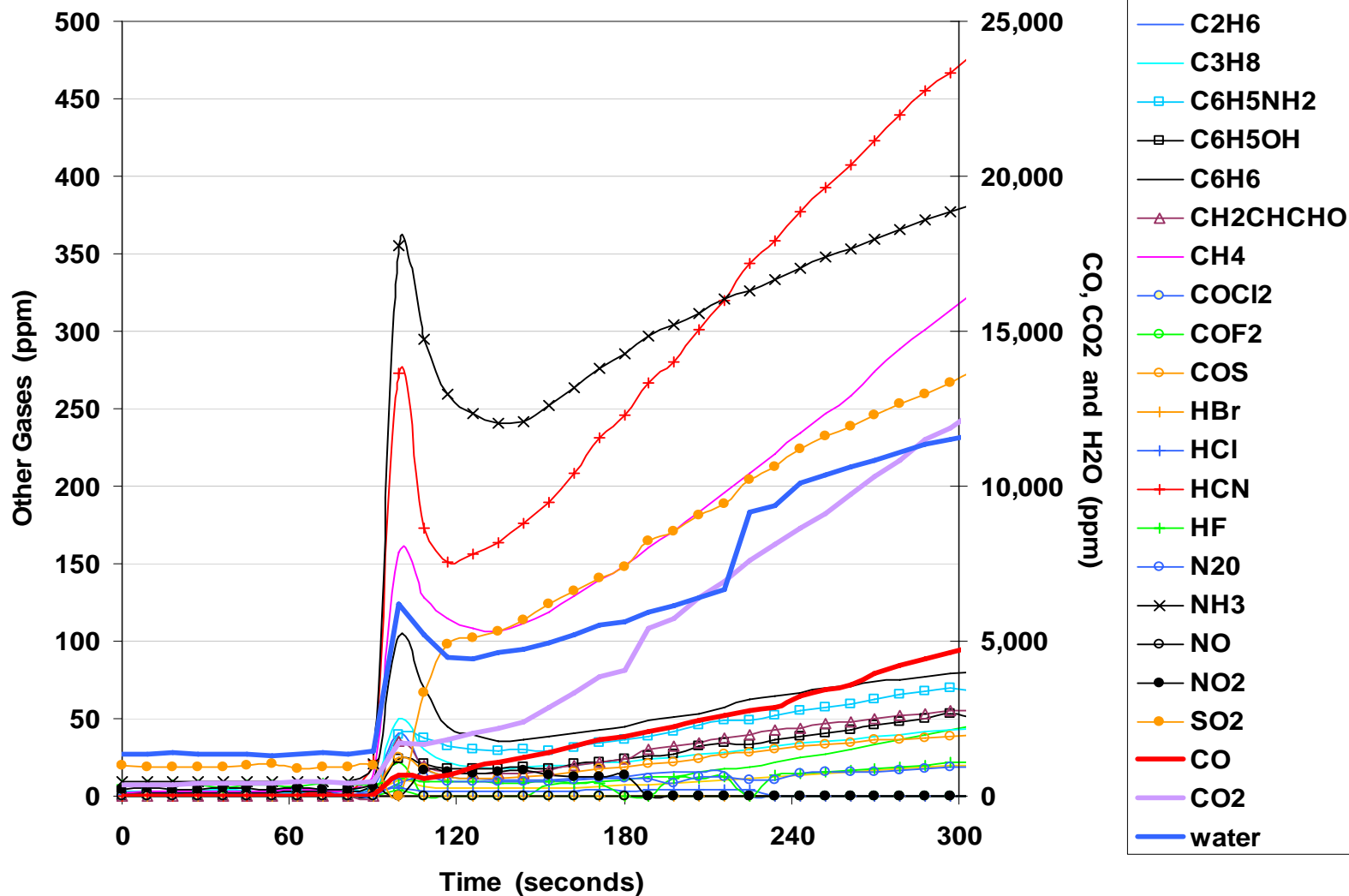
051212 Box Test 2-- FG/Ceramic Barrier/Metalized PVF



Concentration Histories of PAN Insulation System Box Test Obtained by FTIR Analysis



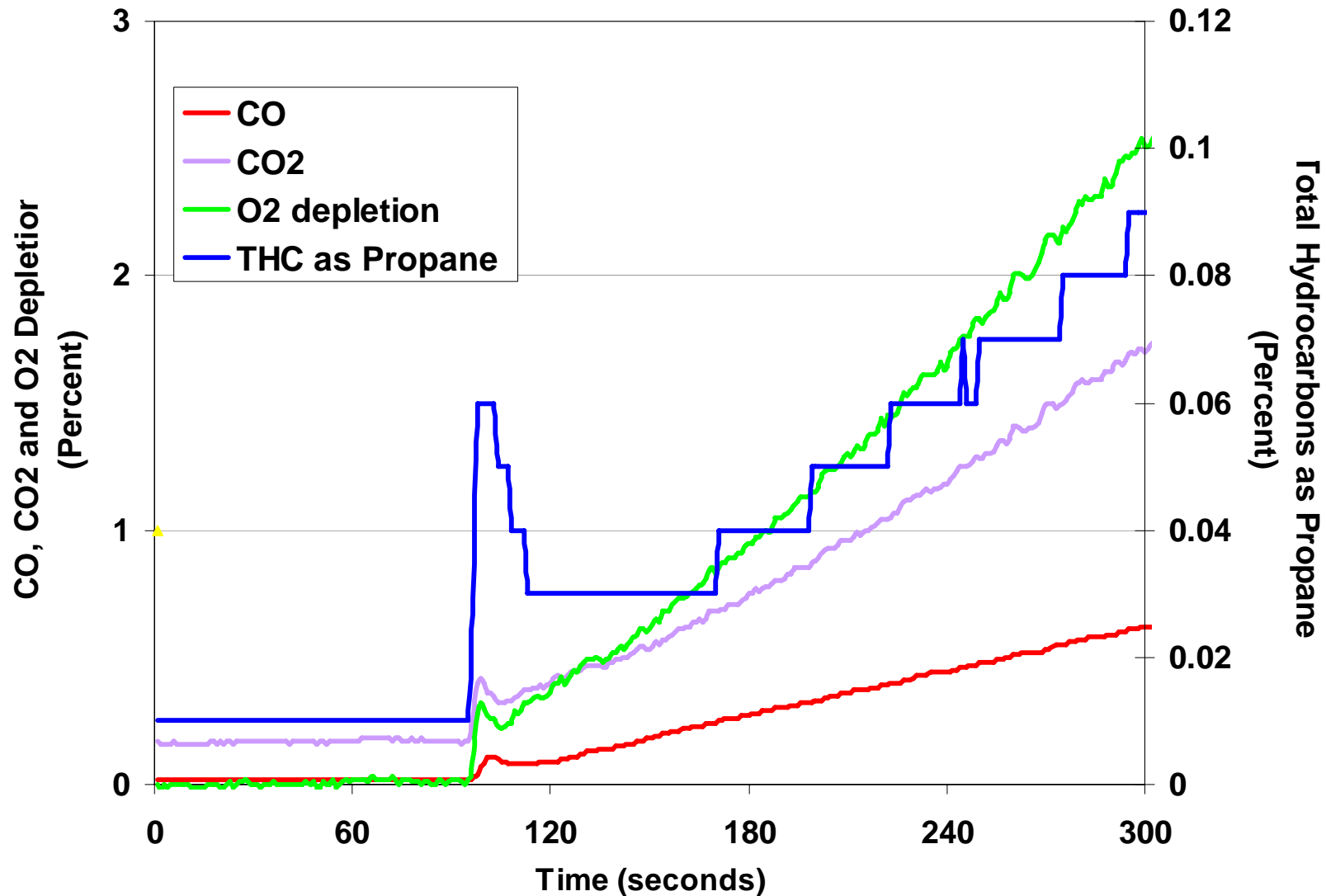
051213 Box Test 5-- PAN/ Metalized PVF



Concentration Histories of PAN Insulation System Box Test Obtained by Gas Analyzers



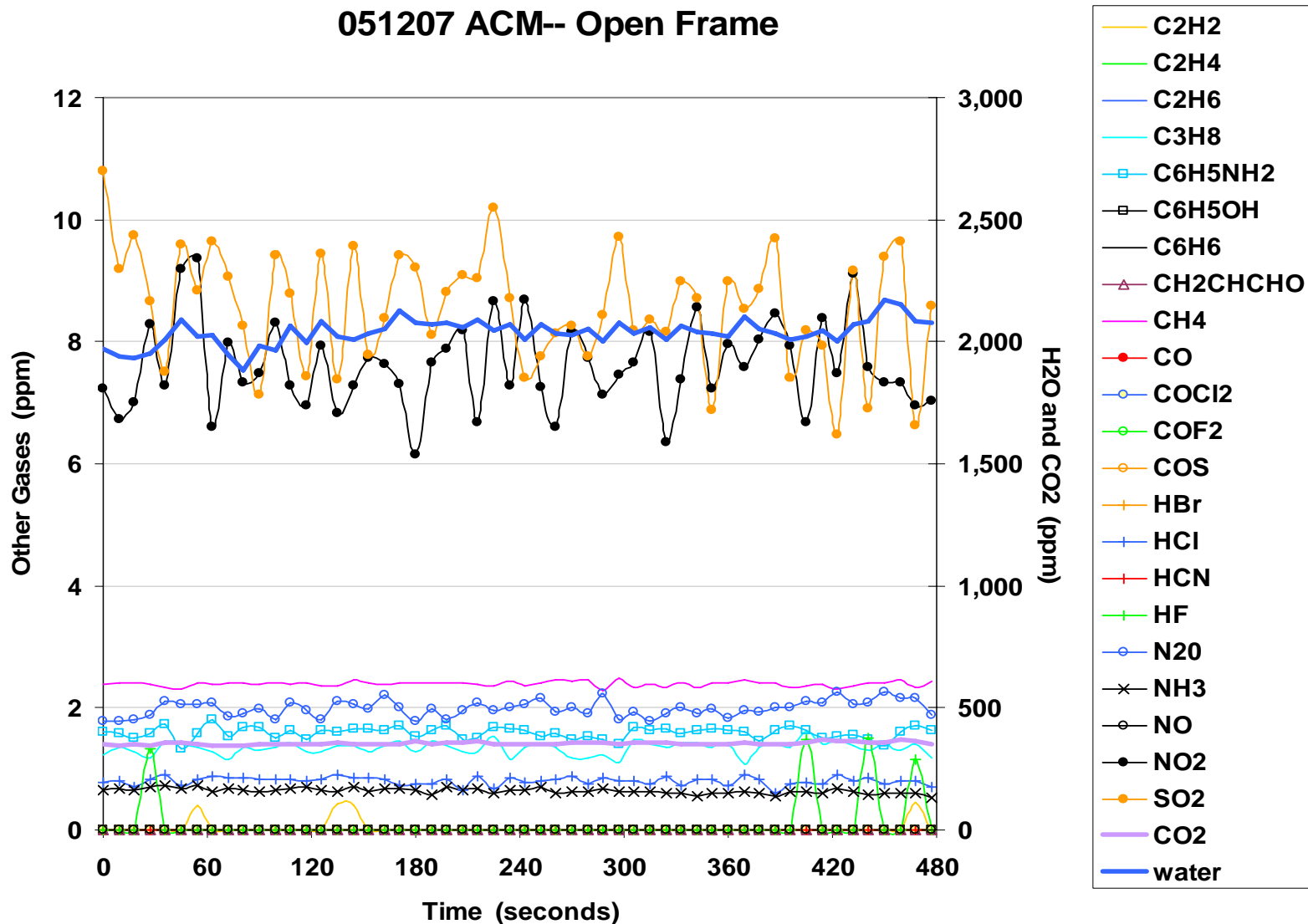
051213 Box Test 5- PAN/Metalized PVF



Concentration Histories of ACM in an Open Frame Obtained by FTIR Analysis



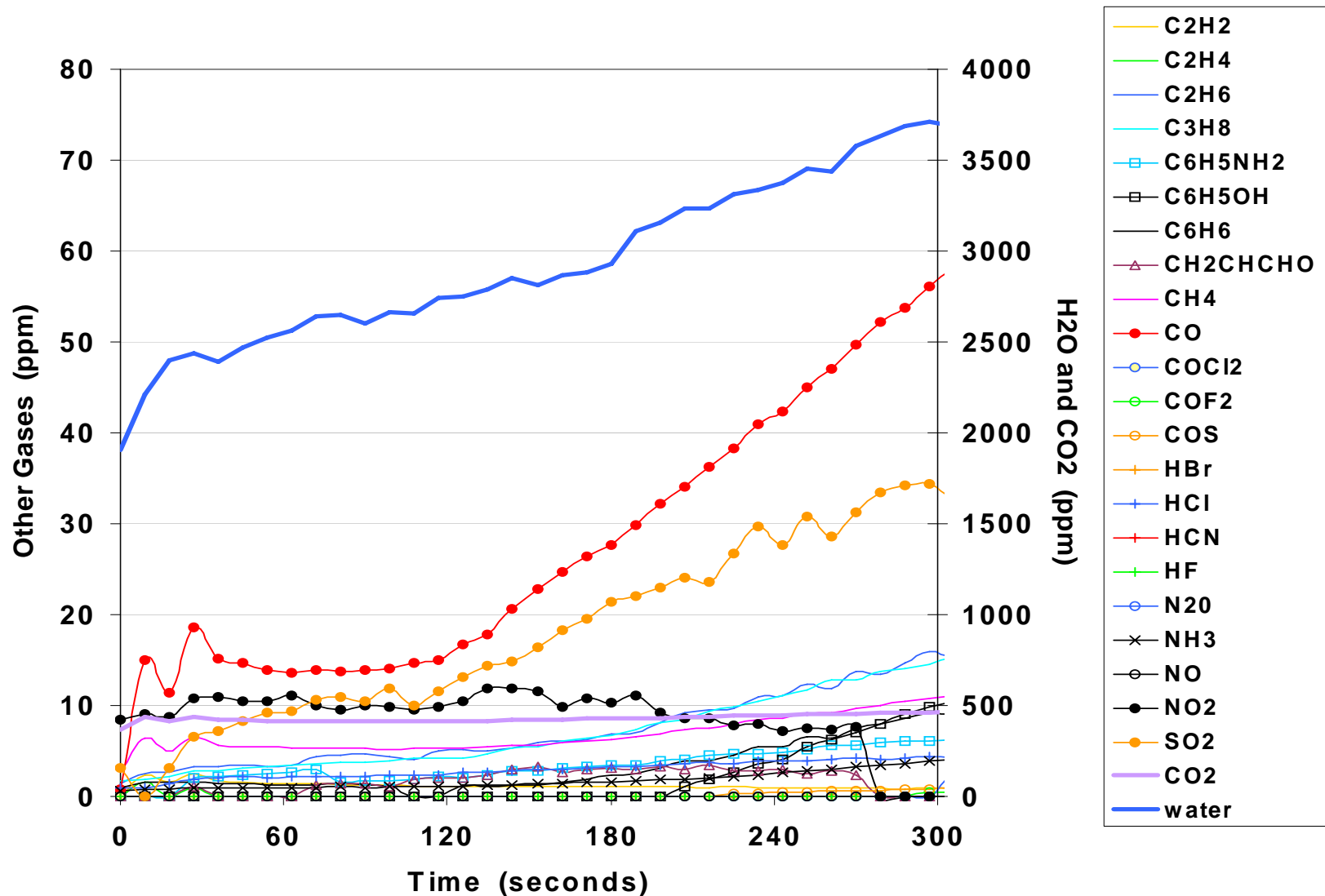
051207 ACM-- Open Frame



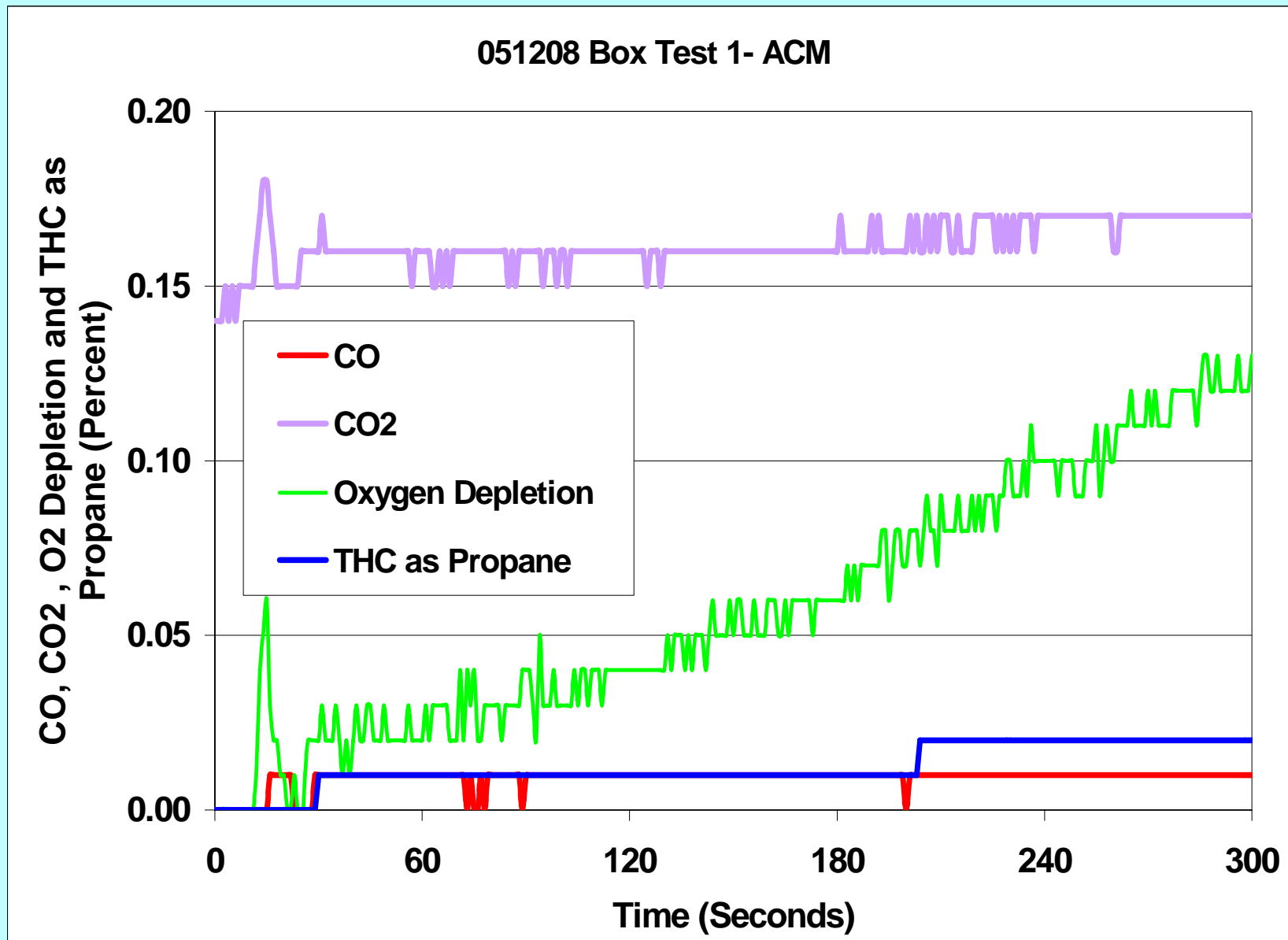
Concentration Histories of ACM Box Test Obtained by FTIR Analysis



051208 ACM-- Box Test 1

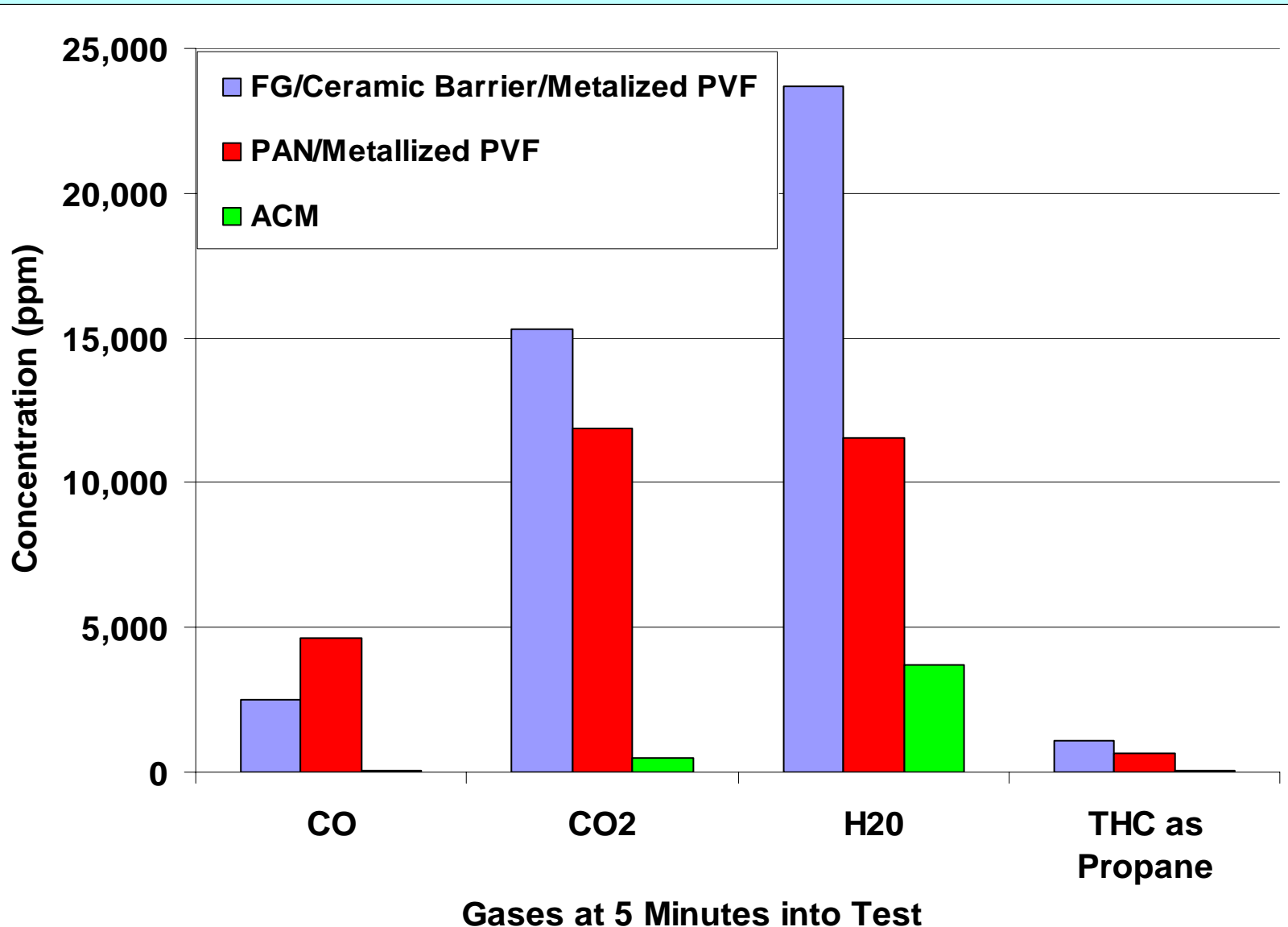


Concentration Histories of ACM Box Test Obtained by Gas Analyzers



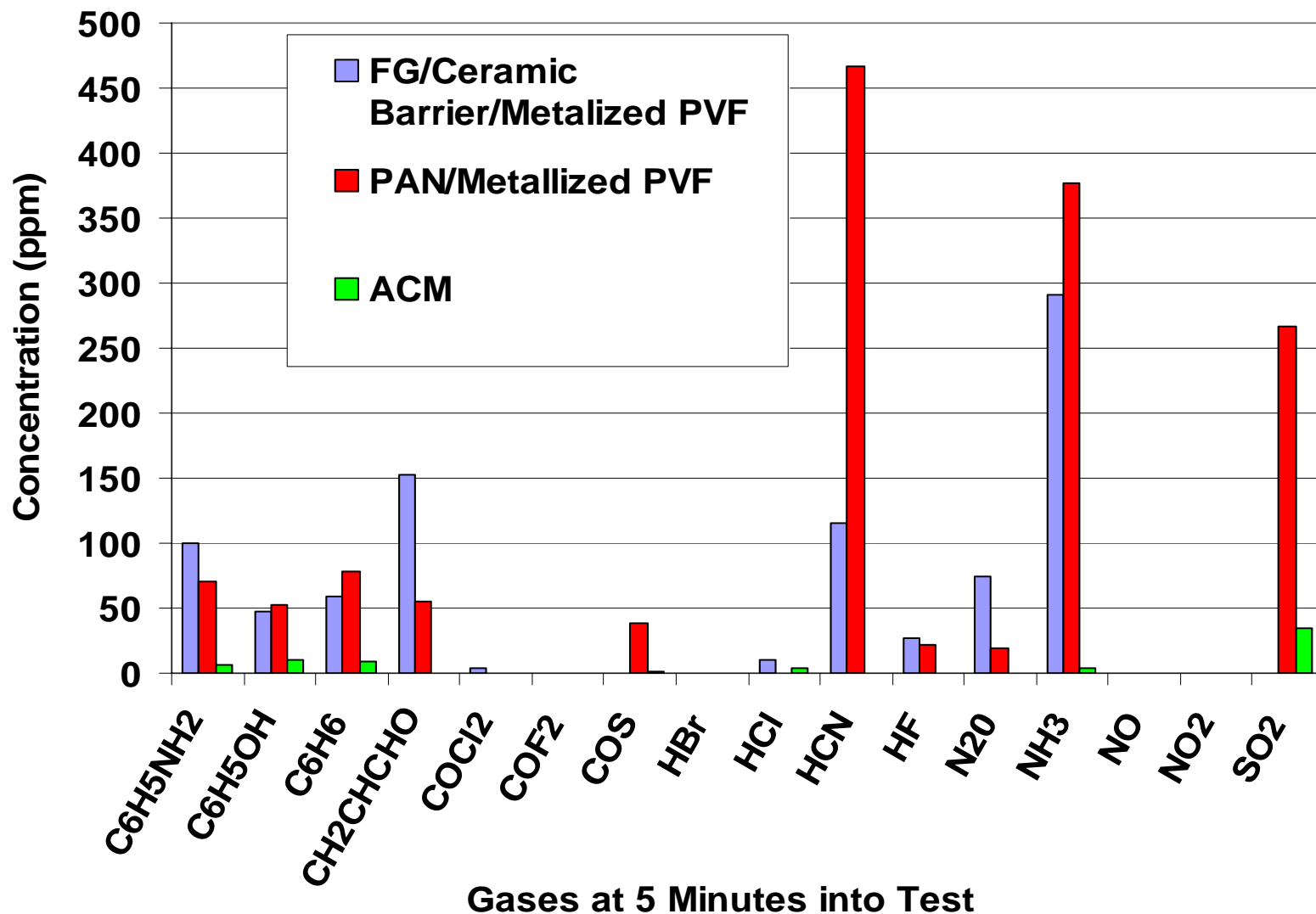


Comparison of Box Test Results at 5 Minutes





Comparison of Box Test Results at 5 Minutes



Full Scale Tests



- Upcoming full-scale tests will provide a scaling factor.
- Scaling factor will be applied to future box tests to predict full scale gas concentration histories.

Conclusion



- A prototype multi-ply structural composite material produced minimal toxic and flammable gases during a 5-minute fire exposure.
- The aluminum skin/insulation configurations generated much higher gas concentrations .
- 7 plies of the 13-ply composite panel were damaged by the fire